

Post
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CWH

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF RESEARCH ADMINISTRATION
RESEARCH PROJECT INITIATION

Date: March 3, 1975

Project Title: Interaction Between Human Aging and Memory

Project No: G-42-624 (Continuation of work previously budgeted under G-42-621)

Principal Investigator Dr. Anderson D. Smith

Sponsor: DHEW/PHS/NIH - National Institute of Child Health & Human Dev.

Agreement Period: From 9/1/74 Until 8/31/76 (End current Proj. Period)

Type Agreement: Grant No. 2-RO1-HD06885-03

Amount: \$16,971 PHS Funds (G-42-624)
5,996 GIT Contrib. (G-42-315)
\$22,967 Total (For 03 Year only)

Reports Required: Annual Progress Report with continuation application;
Terminal Progress Report upon Grant expiration.

Sponsor Contact Person (s):

Merrill S. Read, Ph.D.
Acting Assoc. Dir. for Extramural Programs
National Institute of Child Health & Human Development
DHEW, PHS, NIH
Bethesda, Maryland 20014

Assigned to: School of Psychology

COPIES TO:

Principal Investigator

School Director

Dean of the College

Director, Research Administration

Director, Financial Affairs (2)

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Library

Rich Electronic Computer Center

Photographic Laboratory

Project File

Other _____

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: September 27, 1976

Project Title: Interaction Between Human Aging & Memory

Project No: G-42-624 (continued by G-42-A01)

Project Director: Dr. A. D. Smith

Sponsor: DHEW/PHS/NIH National Institute of Child Health & Human Development

Effective Termination Date: 8/31/76

Clearance of Accounting Charges: ASAP

Grant/~~Contract~~ Closeout Actions Remaining:

- ☐ Final Invoice and Closing Documents
- ☒ Final Fiscal Report
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

Assigned to: Psychology (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
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Security Coordinator (OCA) ✓
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Library, Technical Reports Section
Office of Computing Services
Director, Physical Plant
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other _____

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

APPLICATION
FOR CONTINUATION GRANT

REVIEW GROUP EXP	TYPE 5	PROGRAM R01	GRANT NUMBER (INSERT ON ALL PAGES) HD06885-04
TOTAL PROJECT PERIOD G-42-624			
FROM: 09/01/74		THROUGH: 08/31/76	
REQUESTED BUDGET PERIOD			
FROM: 09/01/75		THROUGH: 08/31/76	

TO BE VERIFIED BY APPLICANT. CHECK INFORMATION IN ITEMS 1 THROUGH 6. IF INCORRECT, FURNISH CORRECT INFORMATION IN ITEM 13.

1. TITLE

INTERACTION BETWEEN HUMAN AGING AND MEMORY

2A. PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR (Name and Address, Street, City, State, Zip Code) SMITH, ANDERSON D GEORGIA INST OF TECHNOLOGY SCHOOL OF PSYCHOLOGY ATLANTA, GA 30332		4. APPLICANT ORGANIZATION (Name and Address, Street, City, State, Zip Code) GEORGIA INSTITUTE OF TECHNOLOGY 225 NCRTH AVENUE, N W ATLANTA, GA 30332	
2B. DEGREE PHD	2C. SOCIAL SECURITY NO. 231-58-5768	5. PHS ACCOUNT NUMBER 1586002023A1	
2D. DEPARTMENT, SERVICE, LABORATORY OR EQUIVALENT SCHOOL OF PSYCHOLOGY		6. TITLE AND ADDRESS OF OFFICIAL IN BUSINESS OFFICE OF APPLICANT ORGANIZATION DIRECTOR OF FINANCIAL AFFAIRS GEORGIA INSTITUTE OF TECHNOLOGY ATLANTA, GA 30332	
2E. MAJOR SUBDIVISION GENERAL COLLEGE			
3. ORGANIZATIONAL COMPONENT TO RECEIVE CREDIT FOR INSTITUTIONAL GRANT PURPOSES 20 OTHER			

COMPLETE THE FOLLOWING (See Instructions)

7. RESEARCH INVOLVING HUMAN SUBJECTS (See Instructions) <input type="checkbox"/> NO <input checked="" type="checkbox"/> YES APPROVED: <u>June 3, 1975</u> DATE		8. INVENTION CERTIFICATION (See Instructions) <input checked="" type="checkbox"/> NO <input type="checkbox"/> YES-NOT PREVIOUSLY REPORTED <input type="checkbox"/> YES- PREVIOUSLY REPORTED	
9. PERFORMANCE SITE (S) School of Psychology Georgia Institute of Technology Atlanta, Georgia 30332		TELEPHONE INFORMATION	
		11A. PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR (ITEM 2A)	AREA CODE 404 TELE. NO. & EXT. 894-2681
		11B. NAME OF BUSINESS OFFICIAL (ITEM 6) Mr. Frank H. Huff	404 894-4622
		11C. NAME AND TITLE OF ADMINI- STRATIVE OFFICIAL (ITEM 15B) Mr. D. L. Allen Dep. Director Contract Administration	404 894-4810
10. DIRECT COSTS REQUESTED FOR BUDGET PERIOD \$ 11, 606.		12B. COUNTY OF APPLICANT ORGANIZATION SHOWN IN ITEM 4 Fulton County	
12A. CONGRESSIONAL DISTRICT OF APPLICANT ORGANIZATION SHOWN IN ITEM 4 5th Congressional District			
13. USE THIS SPACE FOR CORRECTIONS TO ITEMS 1 THROUGH 6. INDICATE THE NUMBER(S) WHERE ANSWER(S) APPLY			

14. CERTIFICATION AND ACCEPTANCE. WE, THE UNDERSIGNED, CERTIFY THAT THE STATEMENTS HEREIN ARE TRUE AND COMPLETE TO THE BEST OF OUR KNOWLEDGE AND ACCEPT, AS TO ANY GRANT AWARDED, THE OBLIGATION TO COMPLY WITH PUBLIC HEALTH SERVICE TERMS AND CONDITIONS IN EFFECT AT THE TIME OF THE AWARD.

SIGNATURES (Signatures required on original copy only. Use ink. "Per" signatures not acceptable.)	15A. PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR	DATE
	15B. OFFICIAL SIGNING FOR APPLICANT ORGANIZATION	DATE 6/11/75

RETURN COMPLETED APPLICATION TO PHS AS SOON AS POSSIBLE:
NO LATER THAN 1 JULY 1975

SECTION II

SECTION II—BUDGET (USUALLY 12 MONTHS)	FROM 9/1/75	THROUGH 8/31/76	GRANT NUMBER HD06885-04
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A. ITEMIZE DIRECT COSTS REQUESTED FOR NEXT BUDGET PERIOD

PERSONNEL		TIME OR EFFORT %/HRS. (c)	SALARY REQUESTED (d)	FRINGE BENEFITS (See Instructions) (e)	TOTAL (f)
NAME (Last, First, Initial) (a)	TITLE OF POSITION (b)				
Smith, Anderson D.	PRINCIPAL INVESTIGATOR				
	Academic year	19%	(to be contributed by Georgia Tech.)		
	Summer quarter	30%	4, 440.	666.	
Graduate research assistants					
	1 - Academic year	14/wk	2, 200.		
	2 - Summer quarter	20/wk	2, 200.		
Undergraduate research assistants					
	(hourly)		500.		
Subtotals			\$ 9, 340.	\$ 666.	
(Indicate cost of each item listed below) TOTAL (Columns (d) and (e))					
					\$ 10,006.
CONSULTANT COSTS (See Instructions)					\$
EQUIPMENT					
					\$
SUPPLIES Clerical supplies \$100.					
Stationary and postage for subject solicitation \$300.					
Materials for stimulus construction \$100.					
Photographic supplies and processing \$100.					
					\$ 600.
TRAVEL	DOMESTIC	Travel to professional meeting			\$ 300.
	FOREIGN				\$
PATIENT COSTS (See instructions)					
Subject costs (expense reimbursement for participants)					\$ 500.
ALTERATIONS AND RENOVATIONS					\$
OTHER EXPENSES (Itemize)					
Publication costs (reprints, technical books, journals, and engraving costs)					\$ 200.
TOTAL DIRECT COST (Enter on Page 1, Item 10)					\$ 11,606.

INDIRECT COST

(See Instructions)

62 % S&W*

% TDC*

*If this is a special rate (e.g. off-site), explain.

Date of DHEW Agreement:

☐ Not Requested☒ Under negotiation with:

D C A A

SECTION II—BUDGET (Continued)

Grant Number

HD06885 - 04

B. Supplemental information regarding ITEMS in the proposed budget for the next period which require explanation or justification. (See Instructions)

1. The salary for the principal investigator in the summer quarter is computed as 30% of the academic year (9 months) salary.
2. There is an increase in the budget from the originally submitted budget which reflects an institutional increase in the salary of teaching and research assistants. The increase only represents \$100 for the academic year and is the first granted increase or cost-of-living adjustment in over five years. The total grant increase totals \$200. and was authorized by Dr. E. H. Loveland, Director of the School of Psychology. The initiation of this cost-of-living increase for graduate assistantships is September 1, 1975.
3. Another increase in the proposed budget is found in the institution-required fringe benefit rate for non-student personnel in sponsored programs. The increase in rate is from 8.77% to 15% and is effective on July 1, 1975. This increase in direct cost is accompanied by a decrease in the indirect cost rate. The authorization for this increase comes from Dr. Thomas E. Stelson, Vice-President for Research.

SECTION III

SECTION III—FISCAL DATA FOR
CURRENT BUDGET PERIOD

(USUALLY 12 MONTHS)

FROM

9/1/74

THROUGH

8/31/75

GRANT NUMBER

HD06885 - 04

The following pertains to your CURRENT PHS budget. Do not include cost sharing funds. This information in conjunction with that provided on Page 2 will be used in determining the amount of support for the NEXT budget period.

A. BUDGET CATEGORIES		CURRENT BUDGET (As approved by awarding unit) (1)	ACTUAL EXPENDITURES THRU 4/30/75 (Insert Date) (2)	ESTIMATED ADDITIONAL EXPENDITURES AND OBLIGATIONS FOR REMAINDER OF CURRENT BUDGET PERIOD (3)	TOTAL ESTIMATED EXPENDITURES AND OBLIGATIONS (Col. 2 plus Col. 3) (4)	ESTIMATED UNOBLIGATED BALANCE (Subtract Col. 4 from Col. 1) (5)
Personnel (Salaries)		8, 732.	1, 896.	6, 836.	8, 732.	
Fringe Benefits		363.		363.	363.	
Consultant Costs						
Equipment		600.	455.	145.	600.	
Supplies		600.	165.	435.	600.	
TRAVEL	Domestic	300.	243.		243.	57.
	Foreign					
Patient Costs		500.	222.	278.	500.	
Alterations and Renovations						
Other		200.	221.		221.	(21.)
Total Direct Costs		11,295.	3,202.	8,057.	11,259.	36.
Indirect Costs (If included in award)						
TOTALS →		\$ 11,295.	\$ 3,202.	\$ 8,057.	\$ 11,259.	\$ 36.

Use space below to:

- B. List all items of equipment purchased or expected to be purchased during this budget period which have a unit cost of \$1000 or more.
 C. Explain any significant balance or deficit shown in any category of Column 5.
 D. List all other research support for Principal Investigator by source, project title, and annual amount.

B. None

C. Deficit in "other" category represents greater than expected reprint cost (publication costs). Excess travel funds will be used to cover deficit.

D. Principal investigator has no other research support.

SECTION IV

APPLICANT: REPEAT GRANT NUMBER SHOWN ON PAGE 1 →		GRANT NUMBER	
SECTION IV—SUMMARY PROGRESS REPORT		HD06885 - 04	
PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR (Last, First, Initial)		PERIOD COVERED BY THIS REPORT	
Smith, Anderson D.		FROM	THROUGH
NAME OF ORGANIZATION		9/01/74	5/31/75
Georgia Institute of Technology			
TITLE (Repeat title shown in Item 1 on first page)			
INTERACTION BETWEEN HUMAN AGING AND MEMORY			

1. List publications: (a) published and not previously reported; (b) in press. Provide five reprints if not previously submitted.
2. List all additions and deletions in professional personnel and any changes in effort.
3. Progress Report. (See Instructions)

1. (a) Publications published and not previously reported:

Smith, A. D. Response interference with organized recall in the aged. Developmental Psychology, 1974, 10, 867-870.

Smith, A. D. Aging and interference with memory. Journal of Gerontology, 1975, 30, 319-325.

(b) Publications in press:

Smith, A. D. Partial learning and recognition memory in the aged. International Journal of Aging and Human Development, in press.

2. No changes.

3. Progress report:

A. Objective. The objective of this research has been and continues to be the examination and subsequent interpretation of the interactions between the aging process and human memory. Recent developments in theory and methodology in the experimental psychology of human long-term memory are being applied in the present experiments to specify the nature of forgetting in the aged. One of the primary objectives has been the empirical investigation of possible retrieval differences between the young and old. The two experiments conducted in the first year of the current grant period have been devoted to this objective. The specific goals of the first year were: (1) to manipulate the storage and retrieval components of recall tasks in order to evaluate the relative importance of such components for correct responding by subjects from different age groups; and (2) to analyze the effects of different kinds of retrieval cues on recall performance.

A third experiment, currently being conducted, is looking at the amount and type of organizational structures used by different aged subjects. Associative, conceptual, and structural relationships are being examined.

The second year of the current grant period will investigate visual imagery in the elderly, including the testing of an imagery-based mnemonic device. The specific goals of the next year's research are: (1) examining the effectiveness of imagery instructions on the recall of both concrete and abstract words; and (2) testing the pegword mnemonic device as an aid to the recall of different aged subjects.

B. Summary report. Subjects in these experiments are alumni of the Georgia Institute of Technology, insuring that the different age groups have similar educational, socio-economic, and occupational backgrounds. In all experiments, no differences between the age groups were found on either the vocabulary or the digit-span subtests of the Wechsler Adult Intelligence Scale. These data are presented in Table 1.

In the first experiment, 80 subjects learned a 30-word list of unrelated words. The relative influence of storage and retrieval was manipulated by varying the amount of time spent in studying the items (storage) and the amount of time spent in trying to remember the items (retrieval). Each item was presented for two seconds for a total presentation time of 60 seconds. Retention tests also lasted 60 seconds, thereby equating the time interval required for both study and recall sessions. An experimental trial consisted of four sessions, with the relative number of study and test sessions varied between groups. One group received three study sessions followed by one test session during each of four trials (SSST). The other group received one study session followed by three test sessions (STTT). Half of the subjects were tested by recall and the other half were tested by recognition. The results of the experiment are presented in Figure 1. Analysis of variance on the recall data revealed a significant interaction between condition (SSST vs. STTT) and age group (aged 20-50 vs. 51-80). Subjects in the older group did not benefit as much as young subjects by having additional retrieval attempts in the STTT condition. This was interpreted as evidence in support of the retrieval deficit in old age. Because of the retrieval deficit, the older subjects benefited to a greater extent by actually studying the items. The younger group, however, seemed to benefit equally from both study and test sessions. This finding replicates earlier research with college-aged subjects. The recognition data failed to show a statistically significant interaction between age and condition, and even showed an opposite trend from the recall data. This result supports the view that recognition is different from recall in the retrieval requirements necessary to perform the tasks.

A second experiment examined the interactions between age and the effectiveness of retrieval cues in recall. Both conditions of cued recall and non-cued recall were given to three age groups differing in age. In addition to the presence of cues at presentation and recall, the type of cue was also varied. The cues were either structural characteristics of the presented words (initial letters) or a higher-order categorical relationship to the presented words.

<u>PRESENTED WORD</u>	<u>CUE</u>
Truck	T_____ (Structural)
	Vehicle (Semantic)

The results of the experiment are presented in Table 2. Because

the literature reports conflicting data concerning the overall advantage of cued recall in the aged, a separate analysis was performed on the condition where cues were unavailable at either input or output and the condition where cues were available at both input and output. These results are depicted by Figure 2. Only the semantic cues were effective in improving recall. Structural cues failed to affect the age-recall relationship. These data further support retrieval as the locus of the age-related memory decline. Recall drops with age (non-cued) because of the greater difficulty in retrieving information from memory. By providing effective retrieval cues at the time of recall (i.e., semantic cues), the retrieval problem is overcome and the memory deficit in the aged is eliminated.

An additional experiment, currently being conducted, is looking at possible differences in organizational processes in the young and old. A list of words containing items related to each other on several dimensions is being presented to different aged subjects for five learning trials. Differential clustering according to the different dimensions (e.g., associative, conceptual, structural) is being measured, in addition to statistical measures of subjective organization. The experiment allows an examination of the kind of organization as well as the amount of organization in the different age groups.

C. Significance. The ongoing research is investigating a possible mechanism for the long-term memory problem seen in old age. The significance of the present research is the specification of retrieval as the possible cause of the age-related memory decline. The present research is showing under what conditions differential forgetting due to retrieval problems in the aged occurs and under what conditions differential forgetting does not occur.

D. Objectives for the current year. In addition to completing the experiment described in the report during the summer, additional experiments will be conducted during the coming year. The specific objectives of these experiments are: (1) to examine the nature of visual imagery in the aged by varying instructions to image and the imagery characteristics of the words in the presentation list (i.e., concreteness); and (2) to test the effectiveness of an imagery-based mnemonic device in the alleviation of the memory deficit in old age.

The undersigned agrees to accept responsibility for the scientific and technical conduct of the project and for provision of required progress reports if a grant is awarded as the result of this application.

6/11/75

Date

Anderson D. Smith

Anderson D. Smith,
Principal Investigator

Table 1
Mean Subject Performance on the WAIS Tests

Group	Age range	Digit span	Vocabulary
<u>Experiment I:</u>			
I	(20-50)	7.65	29.31
II	(51-80)	7.37	31.45
<u>Experiment II:</u>			
I	(20-39)	7.75	28.25
II	(40-59)	7.63	28.17
III	(60-80)	7.25	30.96

Note.- Vocabulary score represents performance on second half (items 20-40) of the WAIS vocabulary list.

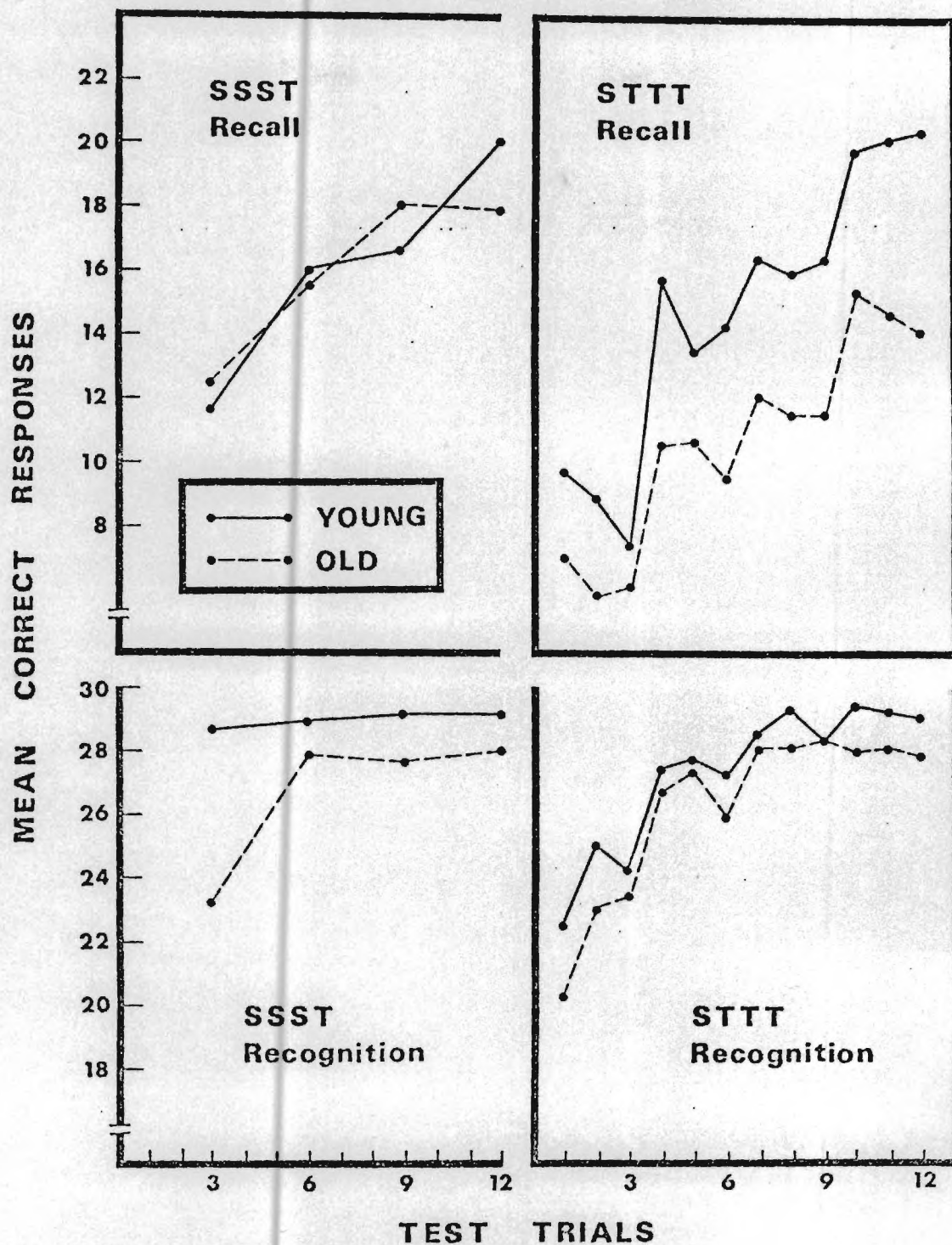


Figure 1. Mean performance for the two age groups on recall and recognition. The conditions of test and presentation are represented in separate frames of the figure.

Table 2
Mean Free and Cued Recall

	Semantic cues		Structural cues	
	Non-cued at input	Cued at input	Non-cued at input	Cued at input
YOUNG (I)				
Non-cued recall	11.7	9.5	10.3	9.0
Cued recall	12.7	12.2	9.2	8.2
MIDDLE (II)				
Non-cued recall	8.0	9.3	8.2	7.7
Cued recall	9.7	12.3	7.5	7.0
OLD (III)				
Non-cued recall	6.0	9.8	6.5	5.8
Cued recall	8.7	11.7	5.2	3.5

Significant effects:

Age, $F(2, 60) = 9.19, p < .01$.

Cue type, $F(1, 60) = 21.14, p < .01$.

Cue type \times Cue presence at output, $F(1, 60) = 37.39, p < .01$.

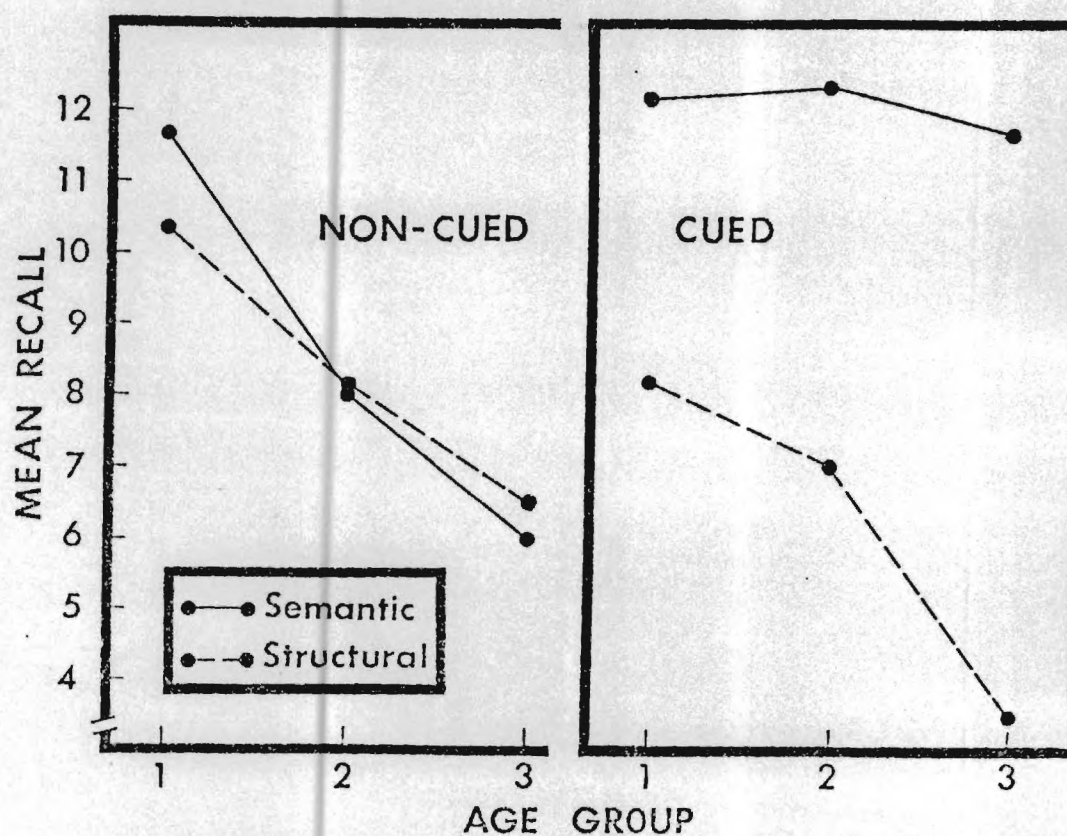


Figure 2. The mean recall of the different age groups for conditions where cues were absent at both input and output and conditions where cues were present at both input and output.

G-42-624

INTERACTION BETWEEN HUMAN AGING AND MEMORY

Anderson D. Smith
School of Psychology
Georgia Institute of Technology

Research assistants: Susan E. Mason
James C. Domangue, Jr.
Flora F. Crew
William E. Albertson

Progress report and renewal proposal for National
Institutes of Health Grant No. HD-06885 from the
Institute of Child Health and Human Development.

September, 1975

SECTION 1

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

LEAVE BLANK

PROJECT NUMBER

RESEARCH OBJECTIVES

NAME AND ADDRESS OF APPLICANT ORGANIZATION

Georgia Institute of Technology, Atlanta, Georgia 30332

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE, AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT, BEGINNING WITH PRINCIPAL INVESTIGATOR

Anderson D. Smith, 231-58-5768
Associate Professor of Psychology
School of Psychology

TITLE OF PROJECT

INTERACTION BETWEEN HUMAN AGING AND MEMORY

USE THIS SPACE TO ABSTRACT YOUR PROPOSED RESEARCH. OUTLINE OBJECTIVES AND METHODS. UNDERSCORE THE KEY WORDS (NOT TO EXCEED 10) IN YOUR ABSTRACT.

Research is proposed to study further the interactions between human memory and adult aging. The focus of the research is the hypothesis which attributes the memory deficit in the elderly to ineffective retrieval from both episodic memory (i.e., the autobiographical record of past experiences) and semantic memory (i.e., the subjective lexicon containing concepts, meanings, and relations).

Two experiments will investigate the retrieval deficit associated with episodic memory. In Experiment 1, differential effects of list length on the storage and retrieval processes of different aged subjects will be investigated. Experiment 2 will determine the conditions necessary for a pre-learned mnemonic device to alleviate the retrieval problem in episodic memory.

Three additional experiments are designed to investigate possible differences in the nature of semantic memory due to age. In Experiment 3, category-conceptual norms will be developed, and these data will be used to infer the structure of semantic memory in the different age groups. Experiment 4 will measure the reaction time necessary to respond to questions asking for information stored in semantic memory. These results should reflect any differences due to age in the retrieval and utilization of semantic information. Experiment 5 will examine age differences in sentence memory and the ability of different age groups to abstract semantic information from sentences.

Retrieval from memory involves search through memory on the basis of some feature of the information sought. Both temporal (episodic) and semantic attributes will be examined in the present research.

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BIOGRAPHICAL SKETCH

(Give the following information for all professional personnel listed on page 3, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME Anderson D. Smith	TITLE Associate Professor of Psychology	BIRTHDATE (Mo., Day, Yr.) 05/03/44	
PLACE OF BIRTH (City, State, Country) Richmond, Virginia, USA	PRESENT NATIONALITY (If non-U.S. citizen, indicate kind of visa and expiration date) USA	SEX <input checked="" type="checkbox"/> Male <input type="checkbox"/> Female	
EDUCATION (Begin with baccalaureate training and include postdoctoral)			
INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED	SCIENTIFIC FIELD
Washington & Lee University Lexington, Virginia	B.A.	1966	Psychology
University of Virginia Charlottesville, Virginia	M.A. PhD	1969 1970	Experimental Psychology
HONORS Phillip Francis DuPont Graduate Fellow, Univ. of Virginia, 1969-70; Society of Sigma Xi, 1971; Phi Kappa Phi Honor Society, 1975; Georgia Tech Outstanding Teacher Award, 1974.			
MAJOR RESEARCH INTEREST Human memory, learning, and cognitive changes with age.		ROLE IN PROPOSED PROJECT Principal investigator	
RESEARCH SUPPORT (See instructions)			

This is a renewal application for NIH Research Grant No. HD06885 from NICHD which is currently funded until August 31, 1976.

RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Starting with present position, list training and experience relevant to area of project. List all or most representative publications. Do not exceed 3 pages for each individual.)

In September, 1970, I joined the staff at Georgia Institute of Technology as an Assistant Professor of Psychology. In July, 1975, I was promoted to Associate Professor. In this capacity, I am responsible for both undergraduate and graduate courses in human learning, memory, advanced learning, and psycholinguistics.

Research projects at Georgia Tech have focused on the processes of human memory, including storage (encoding), organization, and the formulation of retrieval strategies. An attempt has been made to describe these processes in human adult aging. I have served as guest reviewing editor for the journal, Developmental Psychology.

As a graduate student at the University of Virginia, I worked in the area of human memory under the direction of Dr. L. Starling Reid for four years. My doctoral dissertation was concerned with output interference in long-term memory.

Personal publications and papers:

- Smith, A. D. The storage and retrieval processes of human memory. Virginia Journal of Science, 1969, 20, 140.
- Smith, A. D. Differential effects on the storage and retrieval processes of human long-term memory. Paper presented to the meeting of the Eastern Psychological Association, Atlantic City, April, 1970.
- Smith, A. D. Output interference as a function of category size and presentation time at input. Paper presented to the meeting of the Southeastern Psychological Association, Miami, April, 1971.
- Smith, A. D. Output interference with organized recall from long-term memory. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 400-408.
- Smith, A. D. Input order and output interference in organized recall. Journal of Experimental Psychology, 1973, 100, 147-150.
- Smith, A. D. Recognition memory in the aged. Paper presented to the meeting of the Southeastern Psychological Association, Hollywood, Fla., May, 1975.
- Smith, A. D. Response interference with organized recall in the aged. Developmental Psychology, 1974, 10, 867-870.
- Smith, A. D. Aging and interference with memory. Journal of Gerontology, 1975, 30, 319-325.
- Smith, A. D. Aging and the total-presentation-time hypothesis. Paper presented to the meeting of the American Psychological Association, Chicago, September, 1975.
- Smith, A. D. Partial learning and recognition memory in the aged. International Journal of Aging and Human Development, 1975, in press.
- Smith, A. D., D'Agostino, P.R., & Reid, L. S. Output interference in long-term memory. Canadian Journal of Psychology, 1970, 24, 85-89.
- Smith, A. D., & Jarrard, L. E. Activity of brain-damaged rats. Virginia Journal of Science, 1965, 16, 420. (Abstract)
- Smith, A. D., & Robinson, S. N. Input and output order effects in categorized recall. Paper presented to the meeting of the Southeastern Psychological Association, Atlanta, April, 1972.

RESEARCH PLAN

A. INTRODUCTION

1. Objective:

It is the objective of the present research to examine the interactions between human aging and long-term memory. Theoretical and methodological advances in the experimental psychology of memory are being applied in the present experiments to help clarify the nature of the memory decline usually seen with advancing age. Current research is examining the retrieval process in episodic memory as a function of age, and the effectiveness of mnemonic techniques to alleviate the apparent retrieval deficit. In addition, proposed research will attempt to determine the nature of storage and retrieval in semantic memory as a function of age.

The long-term goal of this research is the specification of possible storage and retrieval differences between age groups for both episodic and semantic memory. This is being accomplished by identifying the conditions in which age differences are found and by manipulating variables which are assumed to differentially affect storage and retrieval.

2. Background:

The past decade has brought a large increase in both the quantity and quality of research on human memory. New advances in theory together with sophistication in methodology are providing insight into the way memory operates (Postman, 1975).

Only recently have models of memory been developed which view the human subject as an active processor of information with abilities to selectively store information into memory, to recode and organize memory contents, and to retrieve and utilize information at a later time. These various memory processes are part of a memory structure which consists of several different systems.

For example, most current memory models distinguish between primary memory and secondary memory (i.e., short-term and long-term memory), two memory systems differentiated in terms of capacity and permanence of storage (e.g., Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). Another distinction is often made between episodic and semantic memory, primarily differentiated by the nature of the information stored (e.g., Tulving, 1972; Tulving & Bower, 1974). Episodic memory is conceived as being the autobiographical record of past experiences. Information in episodic memory is recalled on the basis of some temporal feature relating to the time of encoding. Semantic memory is conceived as the "mental dictionary" (Glucksberg & Danks, 1975), the store of information about concepts, meanings, and ideas.

EPISODIC MEMORY

The fact that episodic memory declines with age is well documented in the literature (e.g., Birren, 1964; Botwinick, 1973;

Hultsch, 1971). The nature of this decline, in terms of the various processes which comprise human memory, has been the object of much study and speculation in recent years. Initially, it was assumed that the memory deficit in old age was a result of some failure in primary memory (Welford, 1958). This conclusion was based on the observation that older persons failed to remember information recently acquired while remaining proficient in the recall of events occurring many years in their past. Closer examination, however, revealed that older persons seldom have problems with memory tasks which do not exceed the primary memory span (Talland, 1968). In addition, quantitative measures of primary memory capability (Waugh & Norman, 1965) are relatively invariant across different ages, while estimates of secondary memory decrease through the adult age span (Craik, 1968b). Based on these results it can be concluded that the age-related memory problem involves some aspect of secondary memory, and not primary memory.

Early investigators also suggested that the aged might be more susceptible to interference than younger subjects (Welford, 1958). Interference theory has been one of the most popular explanations of secondary memory forgetting (e.g., Underwood & Postman, 1973). An early experiment by Cameron (1943) supported this position. Cameron compared groups of older and younger subjects in remembering a series of digits. The difference between the age groups was greatest when an interpolated task, presumably a source of interference, was included between the presentation and recall of the digits.

Recent investigators have focused on the specification of interference effects in the aged. Interference can be defined in terms of either proaction (i.e., interference from previously learned material), or retroaction (i.e., interference from tasks interpolated between the input and recall of the to-be-remembered items). There seems to be no support for an increased effect of proactive interference with age. In one experiment, Fozard and Waugh (1969) presented two three-item lists to groups differing in age and found no interactions between age and list order even though performance for all groups declined on the second list.

The relationship between age and retroactive interference is more equivocal. Cameron (1943), cited earlier, found an interaction between retroaction and age, but later investigators have failed to replicate these findings. Gladis and Braun (1958), for example, found no age-correlated retroactive interference effects when the age groups were equated on the basis of vocabulary and learning ability.

The interpolated activity between presentation and recall necessary to produce retroactive interference can be further classified into the presentation of additional material (input) and the recall of other information from memory during the interval (output). Tulving and Arbuckle (1966) referred to these effects as input and output interference. While this distinction is important to clarify possible age interactions with retroactive interference, few experiments have been conducted which consider the effects separately. One group of studies conducted by Taub and his associates does suggest that the aged individual is less able

than young subjects to maintain items in memory while simultaneously making a response, i.e., output interference (Taub, 1968; Taub & Grieff, 1967; Taub & Walker, 1970). Taub's experiments, however, have been criticized because they do not control for differential influences of primary memory. The Taub experiments typically found interference effects only for items in the last part of the input list and these items are assumed to be recalled from primary memory.

Two experiments included in the previous progress report for this project (Smith, 1973) investigated input and output interference in the different age groups using a design which separated primary and secondary memory. In one experiment, a paired-associate probe technique (Arbuckle, 1967; Tulving & Arbuckle, 1966) was used, which, by factorially combining the positions of the pairs at presentation and recall, allowed an examination of output interference for all positions of the input list. No differential output interference or input interference due to age was found for items assumed to be recalled from secondary memory (Smith, 1975). With categorized materials, another experiment failed to find differential output interference due to age (Smith, 1974). While the number of words recalled in this experiment declined across a category recall sequence for three different age groups, no age-related differences in the slopes of the interference functions were found. Differential interference, does not seem a viable explanation of episodic memory deficits seen in the aged.

The conceptualization of the subject as an information processor often distinguishes the two processes of storage and retrieval. The storage of information at the time of learning and its subsequent retrieval at the time of test are two distinct processes which can be separated empirically. Interference is assumed to directly influence the contents of storage, that is, to degrade the memory trace (Postman & Underwood, 1973). Retrieval problems, on the other hand, could be due solely to conditions at the time of recall. Research does seem to show that the elderly are less efficient at retrieval.

Recall vs. recognition. One technique involves the comparison of relative performance of different age groups on two different tasks, recall and recognition. The comparison is based on the assumption that:

"...recall involves some processes in common with recognition but one (or more) additional process as well. A likely candidate for the latter is a search process." (Murdock, 1974, p.66)

If the effect of age on recall is to decrease the ability to retrieve, then the effect of age on recognition should be smaller than on recall (Kintsch, 1970; McCormack, 1972; Smith, 1970).

Schonfield and Robertson (1966) compared age groups on recall and recognition; and while recall scores showed a significant and systematic decrease with increases in age, no differences between the groups were found with the recognition task. Schonfield and Robertson (1966) suggested retrieval as the process impaired by age. If aging influenced acquisition or storage, both tasks should have been affected. These results have been replicated by Craik (1972) with the addition of signal-detection measures of recognition

performance. Wicklegren (1975) also found no differences in the retention functions between age groups in a continuous recognition procedure.

McNulty and Caird (1966) have argued that the results of the recognition experiments can be accounted for by a storage decrement based on the assumption that a subject can learn parts of the presented information. This partial learning, while not sufficient to adequately recall the items, is sufficient to produce correct recognition (McNulty, 1966; McNulty & Caird, 1967; Laurence, 1967). In one experiment which was designed to differentiate between the retrieval and partial learning hypotheses, Hartley and Marshall (1967) tested an older group on two successive recognition tests. One of the tests contained distractor items (i.e., incorrect alternatives) which were structurally similar to the presented items. Recognition performance was the same on both lists which seems to support the retrieval hypothesis. The experiment, however, included no younger group comparison which is necessary to assess age-related effects. The same subjects also received both test lists and always in the same order. In addition, there is the possibility that partial storage is based on attributes other than structural characteristics of the items.

An experiment is reported in the following progress report which examined the partial-storage hypothesis as a viable alternative to the retrieval hypothesis by minimizing the opportunity of different age groups to use partial information while performing a recognition task. Partial storage was minimized by using stimulus materials which were well integrated into units and thus difficult to store partially. Since partial storage might be based on attributes other than structural aspects of the words, semantic distractors (e.g., synonyms) as well as structurally related distractors were included in the test list.

Components of recall. Another technique used to separate storage and retrieval involves an independent examination of various components in the recall protocols of different age groups. Craik and Masini (1969) have found that the recall of higher-order units (e.g., vehicles) was unaffected by age while the recall of the components of these units (e.g., truck, car, boat) remained unaffected. Because words-per-unit is a measure of storage, and recall of higher-order units is a measure of retrieval (Tulving & Psotka, 1971), Craik and Masini (1969) concluded, "it is the retrieval process which is impaired by age." It is interesting to note that while age had its effect on the number of chunks recalled, measured IQ was correlated with the size of the chunk, or the number of words recalled per unit. The ability to organize as a measure of storage is correlated with IQ and not age.

Laurence (1966) measured the ability of subjects to store or chunk by measuring Tulving's (1962) "subjective organization" (SO) in the recall protocols of the different age groups. Again, no differences between age groups were found in the ability to code and organize as reflected by the SO measure. Subjective organization, however, is only one of a number of different measures of organization and many investigators believe it lacks the precision of others

which are available (e.g., Hultsch, 1971). An experiment is currently being conducted which examines other measures of organization and attempts to insure that Laurence's findings are generalizable to other measures and not a peculiarity of the SO measure.

It is possible that differences in the type of organization rather than the amount of organization could be found in older persons. Denny (1974) found no interaction between type of organization and age, but used only similarity and complementary relationships among the items. The current experiment, discussed in the progress report, is using different kinds of organizational structures built into the presentation list and examining differential clustering according to these dimensions by different age groups.

Cued vs. non-cued recall. A third method used in memory research to separate storage and retrieval employs pre-recall cueing (Tulving & Pearlstone, 1966). Laurence (1967) presented 36 words from six different categories for single trial recall and found large differences between young and old subjects in non-cued recall. When category names as cues were provided at the time of recall, however, no differences in recall were found. Recall differences due to age were eliminated by reinstating retrieval cues based on the list structure at the time of recall.

Conflicting results have been reported by Drachman and Leavitt (1972), but their experiment used a different form of list organization. While differences were found between the age groups, the recall cues were the initial letters of the to-be-remembered words. These cues would not be effective at the time of recall if the items were stored along attributes other than the alphabetical feature. Conceptual or semantic cues, rather than structural cues (e.g., initial letters), might provide access to the items. Like Laurence (1967), Hultsch (1975) found no differences between age groups in cued recall of higher-order units using semantic cues (category names). Research has shown that in order for a cue to be effective, it should reflect an organizational structure set up at the time of presentation (Tulving & Osler, 1966). An additional experiment is reported in the following progress report which manipulated the presence of cues both at input and at output. In addition, different kinds of cues were used, ones representing structural features of the items as in the Drachman and Leavitt (1972) experiment, and ones pertaining to semantic characteristics of the items such as used by Laurence (1967) and Hultsch (1975).

Total-presentation-time hypothesis. The total-presentation-time hypothesis (e.g., Cooper & Pantle, 1967) predicts that lists equated in total study time will have equivalent recall regardless of the rate of presentation or the length of the list. The hypothesis predicts, for example, that a 30-item list presented at a one-second rate would have equal recall to a 15-item list presented at a two-second rate. In both cases presentation time for the list is 30 seconds and this total time parameter is assumed by the hypothesis to predict the level of recall. Murdock (1960) has reported a series of experiments which seem to support the hypothesis, and in addition, to show that the relationship between recall and total time is a

linear one. The equation developed by Murdock (1960) is:

$$R = .06t + 6.1$$

where R is the level of recall and t is total presentation time.

A large parametric study was performed by Roberts (1972) which more carefully examined the predictions of the total time hypothesis. Roberts factorially combined four list lengths and five presentation times with total time varying from five to 320 seconds. The experiment failed to support the part of the total-time hypothesis which predicts a linear relationship between recall and total time. Instead, Roberts found a negatively accelerating monotonic function. The invariance part of the hypothesis, however, has received support from various experiments (Murdock, 1974).

The crucial assumption behind the total-time hypothesis is that list length and presentation time (the two variables which combine to form the total-time parameter) have similar effects on memory. Shiffrin (1970), however, has suggested that list length, unlike presentation time, probably affects the retrievability of the words from memory at the time of recall. In other words, the probability of finding a word in memory and recalling it decreases as the number of words in memory increases. Presentation time, on the other hand, directly determines the strength of the memory trace stored at the time of input (Murdock, 1974). Presentation time, therefore, should affect storage of information in memory, while list length should affect the accessibility or retrievability of the information at the time of recall.

An additional experiment was designed to examine the validity of the total-time hypothesis when subjects of different ages were used. Evidence from different sources is showing that the older person is both less effective at using the time available to perform cognitive tasks (e.g., Botwinick, 1973), and at the same time, less efficient at retrieving information recently presented into memory. If reducing the presentation time or increasing the length of the list differentially affects subjects from different age groups, then the total-time hypothesis, which is based on these two variables, must in turn differentially predict the recall of the different age groups. In other words, the invariance assumption in the total-time hypothesis might not hold for the older age groups. In a comparison of two lists, for example, with both list length and presentation rate varying but total study time invariant, the condition with the longer list but faster rate would have poorer recall in the older group than the condition with the shorter list and slower rate. The reported experiment (see following progress report) manipulated list length and presentation rate in addition to age. Because of the results of this experiment, as discussed in the later section, an additional experiment is being proposed to help clarify the interaction between list length and age.

Study and recall requirements in free recall. The final method is probably the best since it manipulates both storage and retrieval as independent variables. Using this method, study (storage) and recall (retrieval) components of free recall tasks are separated (Hogan & Kintsch, 1972; Tulving, 1966; 1967). Tulving (1967) divided subjects into three age groups. The first (STT) received

one presentation of the items followed by three successive recall tests. The second group (STST) received one presentation, followed by recall, followed by a second presentation, and followed by a second recall. A third group (SSST) was presented the list three times before a single free recall test was given. All three groups showed equal overall recall performance. Tulving discussed the results in terms of availability (storage) and accessibility (retrieval) of the items. The study trials aided the subjects in terms of storage or making the items available, and test sessions were equally important in learning by aiding retrieval or making the items accessible at the time of recall.

Further comparison of STTT and SSST groups comes from an experiment by Hogan and Kintsch (1972). In this experiment, both recall and recognition tasks were used. The results supported Tulving's conclusions by the fact that the SSST and the STTT groups were equal in recall performance. However, the SSST method produced better recognition performance than the STTT method. The beneficial effect of the STTT method on retrieval was lessened when the recognition task was used.

An additional experiment will be reported later which combined the use of this method with age as an additional independent variable. In addition to method of presentation (SSST vs. STTT), the method of test was also manipulated (recall vs. recognition). It was hypothesized that the older groups would not benefit equally in recall by the SSST and the STTT conditions. Because the older groups have a retrieval deficit, they should not benefit as much by the STTT condition. Study trials should have a greater effect on recall than the test trials.

Mnemonics. If the elderly have a greater problem in retrieving information from episodic memory, then mnemonic techniques, as retrieval aids, should benefit older subjects even more than the young.

The procedure is as follows. First the subject memorizes a number rhyme (e.g., one is a bun, two is a shoe, three is a tree, etc.). He is then given a list of items to remember. The subject is instructed to associate (usually through visual imagery) the peg-word in the mnemonic device with the to-be-remembered word. Then, at the time of recall, retrieval is accomplished by reciting the mnemonic device and recalling the words associated with the element peg-words.

Mnemonic devices are one of the oldest methods for improving memory (Yates, 1966). Experiments with college-aged subjects have consistently found large improvements in recall when using mnemonics (Paivio, 1968; 1969; 1971; Delprato & Baker, 1974; Santa, Ruskin, & Yio, 1973). While no studies have been conducted looking at the differential effectiveness of mnemonics in different adult age groups, studies have been done which vary instructions to mediate in a paired-associate task. Hulicka and Grossman (1967), for example, studied the use of mediation in different age groups. Elderly subjects were found to improve their performance with mediation instruction more than younger subjects, with the greatest improvement coming if the subjects were allowed to develop their own mediators. Rowe and Schnore (1971) found that older subjects spontaneously use

mediation less often than younger subjects, and rarely report the use of imagery mediation. Mediation presumably aids retrieval by providing a route to memorized information. Because the older subjects use mediation less often than younger subjects, the use of mnemonic devices should especially benefit older subjects in retrieving.

An experiment which tests the effectiveness of the pegword mnemonic device as a retrieval aid in three age groups is reported in the later section of this report. In addition, an experiment is proposed which examines the conditions necessary to produce mnemonic effects in the different age groups. Variables which are assumed important in determining mnemonic effectiveness will be manipulated: (a) the pacing of the task (e.g., Monge & Hultsch, 1971; Treat & Reese, 1974); (b) the concreteness of the pegwords in the device, i.e., one is a bun vs. one is fun (Paivio, 1971); (c) the concreteness of the to-be-remembered word list (Paivio, 1971); and (d) instructions to use either imagery or verbal association. If the subjects are instructed to use imagery rather than verbal association, the older group should perform poorer than the younger group since imagery mediation has been found less effective for the older subjects (Hulicka & Grossman, 1967).

SEMANTIC MEMORY

The research discussed so far has dealt for the most part with what Tulving (1972) calls "episodic memory." This memory system represents the autobiographical record of one's past experiences. Perceived events are dated and placed in temporal order within this system. Traditional recall and recognition procedures ask the subject to retrieve information from episodic memory. "Was this item seen before?" "What were the words you recently saw in the list?" These questions are asking for a temporal referent and this is the content of episodic memory.

Semantic memory, on the other hand, is the subjective lexicon. It contains information about objects, concepts, relations, and facts. A question like "Is a cat an animal?" seeks information about the subjective nature of the concepts cat and animal, and this is the content of semantic memory. Retrieval from semantic memory is even more important to everyday functioning than retrieval from episodic memory. Words chosen for language use and the comprehension of verbal information depend on the effective retrieval and utilization of the contents of semantic memory.

Very little work has been done on the nature of semantic memory in different age groups. Previous research has concentrated on tasks which require subjects to produce as many words as possible given some cue (e.g., words containing a single specified syllable, Reigel & Birren, 1966) in a fixed interval of time. In general, these studies show that older subjects recall fewer items from their semantic memories. The results, however, can lead to many different interpretations. The results could reflect the fact that older subjects are more cautious in responding (Slater & Scarr, 1964); the results could reflect an increase in the reaction time required for the older person to respond and to make decisions (Botwinick, 1973); the results could reflect differences in the structure of

semantic memory, such as an increased size of the lexical categories (Collins & Quillian, 1969; Landauer & Meyer, 1972); or the results could reflect an increased time to retrieve, such as found with episodic memory tasks (Anders & Fozard, 1973).

Eysenck (1975) reported an experiment which attempted to specify more clearly the nature of the semantic memory deficit in the aged. Both young and old subjects performed a semantic task which involved the recall of an instance starting with a specified letter from a designated category. For example, "Fruit - A" was shown and the subject responded "apple." Other subjects performed a semantic recognition task, requiring a decision as to whether the item specified was an instance of the category. With response time as the dependent variable, there was a differential effect of age on recall and recognition. The older subjects responded more slowly on the recognition task, but not on the recall task. Eysenck (1975) concluded that the older subjects required a longer time to reach a decision (recognition). It still seems unclear, however, why no effect was found in recall since decision is assumed to be a process common to both recall and recognition (Murdock, 1974).

Another finding in the Eysenck (1975) experiment was that the difference in response latencies between words of high and low dominance was less for the older subjects. Response dominance was determined by the rank position of the items in the Battig and Montague (1969) category norms. Rank represents the number of subjects that gave a specific instance to the category name during a 30-second period. The Battig and Montague norms, however, were based on college students and it is possible that the norms are less valid for older age groups. The category norms are a good approximation to the subjective lexicon, and if the nature of the lexicon depends on age, then the norms are inappropriate for use with older subject groups. For example, if the subjective categories for the older subjects were larger because of extra exposure to instances, this could account for the longer response latencies in the semantic recognition task. Collins and Quillian (1969) have found that it takes a longer time to give a positive response to the statement, "A robin is an animal", than it does to the statement, "A robin is a bird." One interpretation of this result is that retrieval time from semantic memory depends on the size of the searched category (Landauer & Meyer, 1972). If the category sizes are larger for the older subjects, the category norms would show greater variability and less dominance than ones collected with college-aged samples. In other words, it is not just the number of responses which might vary between age groups (e.g., Reigel & Birren, 1964), but the type of responses given. If the lexicon of older subjects is different, it would be reflected in the actual responses made to the category name. Eysenck's finding that older subjects' response times were less influenced by category-norm dominance suggests this possibility. As a first step in investigating semantic memory in the aged, an experiment is proposed to collect category-normative data and compare these data across adult age groups.

Another experiment is proposed to examine differences in semantic memory due to age. In this experiment, different age groups will be asked to recognize instances of categories as in the Eysenck study. In addition, the size of the categories will be varied.

Two types of categories will be included in the experiment. First, categories will be used which are easily enumerated (e.g., days of the week, states). In addition, categories will be used where the instances are difficult to enumerate (e.g., animals, vehicles). Within these two types of categories, size will be varied according to the norms. If the difference in retrieval time is due to a greater time required for the older person to make decisions, it is predicted that category size will not differentially interact with age. Decision occurs after the search, and decision time should not be influenced by the size of the searched category. If, on the other hand, the longer latency is due to a larger subjective lexicon on the part of the older subjects, the normative size of the categories should interact with age. The larger the normative category, the

greater the chance of the older group to have experienced more instances. The older group, for example, would have more animals to search, and thus take more time to respond. These two hypotheses are represented by Figure A-1.

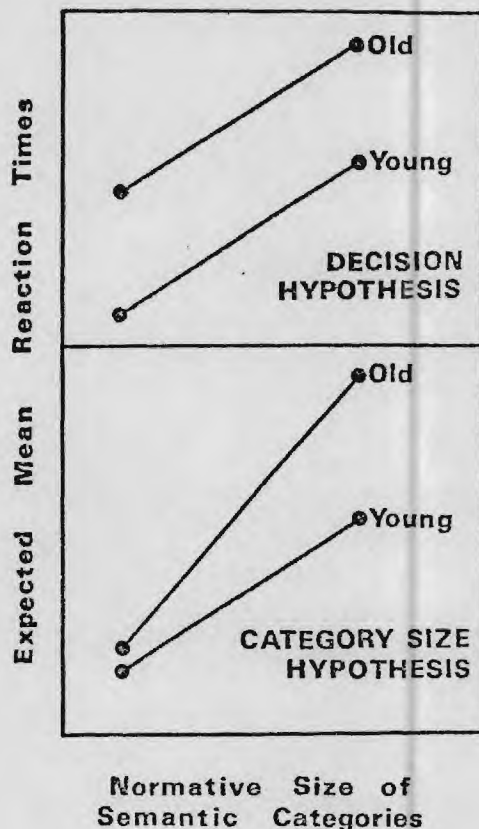


Figure A-1. Predictions for semantic reaction time for the different age groups.

The experiment can also differentiate between possible storage differences (bigger categories) and retrieval differences (subjects take more time to search). Both of these hypotheses, unlike the decision hypothesis, would predict larger age differences for the larger categories, i.e., an interaction between category size and age. The category size hypothesis can be differentiated from the retrieval hypothesis, however, by comparing the age groups on the exhaustive (easily enumerated) categories. Given the same number of items to search, it should still take the older group longer to search if faulty retrieval were supported by the results. The category size hypothesis, however, predicts equal latencies for the age groups on the exhaustive categories. It will take the older group the same amount of time to search the 12 months of the year as the younger group, for example, because category size in this case is equivalent. The details of the methods of procedure

will be discussed in a later section.

Another important aspect of semantic memory is the ability to abstract ideas from sentences. Bransford and Franks (1971) have found sentence memory to be primarily a collection of complex semantic ideas instead of exact representations of the sentences as presented in a memory task. In the encoding of language, therefore, people remember more than they actually hear. It is also true that the ease of abstraction determines the degree to which semantic ideas can be

retained (Kintsch & Monk, 1972). This psycholinguistic research is indicating that storage into semantic memory is more than a copying process. Semantic ideas are abstracted and encoded into semantic memory.

If an understanding of storage and retrieval from semantic memory in older subjects is to be achieved, the ability of older subjects to encode semantic information and to abstract linguistic ideas must be determined. Older subjects seem to be especially affected when text material (sentences) is presented for recall (Craik, 1968a). In one from a series of experiments, Craik (1968a) varied both age of the subjects and approximation of the word lists to English sentences and concluded:

"...that the older subjects were at a greater disadvantage when dealing with material that is highly amenable to chunking, the higher approximations to English." (p. 147)

Other more recent experiments discussed earlier in this report, however, have shown that organizational ability might not differ between age groups. In the Craik experiment, the manipulation was approximation to English text. While this increases the ease of organization into semantic memory, it also increases the extent to which word lists approximate sentences which are encoded differently from random word strings (Barclay, Bransford, Franks, McConnell, & Nitsch, 1974; Bransford, Barclay, & Franks, 1972; Bransford & Franks, 1971). Bransford and Franks (1971), for example, found that college-aged subjects in a sentence recognition test picked sentences which were not presented in the list if they contained abstract, semantic ideas which were presented in other sentences. In other words, the deep structure of the sentences are stored in memory rather than the surface structure (Glucksberg & Danks, 1975).

If the elderly are handicapped at abstraction of these ideas, two possible results could occur in a sentence memory recognition task. First, the older group might actually do better on the recognition test. That is, they would tend to reject sentences which contained complex combinations of ideas, while younger subjects would select them as presentation sentences. This would occur if the older subjects treated the task more as a rote task. The rote memorization would produce better recognition performance (e.g., Eagle & Leiter, 1965), since the abstraction process would not interfere with the recognition of the sentences. Another possible finding would be that recognition performance in the older group would not be as predictable on the basis of the complexity of the sentences. The older group would do worse on the task, and in addition, performance would be unrelated to the sentence structure. An experiment is proposed which will examine sentence memory and semantic abstraction in three different adult age groups.

3. Rationale:

Our understanding of the retrieval process in human memory has advanced in recent years, and research using age as an independent variable suggests that a retrieval deficit could account for much of

the memory decrement seen in older persons. Increased forgetting is a major frustration for older persons (Botwinick & Storandt, 1974) and it is vitally important for a full understanding of the age-related memory deficit that the phenomena relating to retrieval in both episodic and semantic memory be examined in the laboratory.

The approach of all the experiments completed and proposed in this report is to determine possible Age x Experimental treatment interactions. Instead of focusing on absolute differences between age groups, the focus is on relative differences produced by manipulation of several variables. This approach to the experimental study of age effects has been labeled one of the most effective developmental research strategies (Hultsch, 1971).

Some have argued that longitudinal analysis is the best approach for examining age-related differences. In order for longitudinal analysis of memory and age to be practical, however, cross-sectional studies must first point out that differences exist between the young and old. It is hoped that the reported and proposed research might provide insight into age differences which could be programmed into future longitudinal investigations. The argument for longitudinal research has been bolstered by findings that many of the cross-sectional findings dealing with intellectual functioning were negated by longitudinal research. Very tentative recent results, however, are suggesting that longitudinal and cross-sectional experiments show similar results on recall tasks (e.g., Arenberg, 1971).

The present research examines cognitive functioning at all ages rather than making simple comparisons between the "very young" and the "very old". This is especially important since some age deficits are seen at age 40 (e.g., Hultsch, 1971), while others are not seen until age 60 (e.g., Fozard, Nuttal, & Waugh, 1969).

Finally, emphasis in this research is placed on the careful selection of subject samples. All subjects must be non-institutionalized, healthy, and active members of their communities. Psychometric data is collected to insure the comparability of the different age groups.

4. Comprehensive Progress Report:

a. Period. The period covered by this report extends from August 1, 1973 to July 31, 1975. This period includes one half of the currently approved grant period which extends through August, 1976. Experiments to be conducted in the second year of the current project period are described briefly in the detailed report.

b. Summary. The research conducted during the period of this report primarily deals with the hypothesis that differential retrieval from memory accounts for the deficit seen with increasing age. When a recognition task or a semantic cued recall task were used, differences between the age groups were eliminated. The fact that no differences were found with these test conditions implies that the memory problem in older subjects is not due to storage or problems encountered when trying to learn the material, but rather is due to retrieval problems encountered at the time of test.

An additional experiment was conducted which independently varied

study trials (storage) and test trials (retrieval) during a multi-trial learning task. Again, a larger decrement was found in the older group when the task involved the greater retrieval component.

In another experiment, presentation time and list length, two variables which were expected to affect storage and retrieval differentially, were manipulated, but with no differential interactions with age. Likewise, an imagery-based mnemonic device did not differentially benefit subjects in the older age groups.

Experiments are currently being conducted which are investigating (a) the use of visual imagery in older subjects as a possible explanation of the mnemonic failure, and (b) the organizational structures used by different age groups.

c. Detailed Report. The focus of the five experiments to be reported in this section was to examine possible retrieval differences in episodic memory between different age groups. Procedures were used which are assumed to separate empirically storage and retrieval, and the results of these procedures, taken collectively, indicate a decrease in the efficiency of the retrieval process in old age.

Subjects. Subjects in the following experiments were solicited from two sources. The first approach involved selecting volunteers from the relatively large population of Georgia Tech alumni residing in the Atlanta area. This subject pool was used when it was necessary for the subjects to visit the laboratory for the experimental session. The alumni sample provides an especially homogeneous group in terms of educational, socio-economic, and occupational backgrounds.

Subjects were also obtained from various civic, church, and social clubs in the Atlanta area. With this approach, group experiments are conducted at the designated time and place of the club meeting.

In order to insure some minimum level of processing capacity, the vocabulary and digit span subtests of the Wechsler Adult Intelligence Scale (WAIS) were administered in conjunction with the experimental procedures. These measures have been shown to be relatively invariant across the adult age span and thus provide a rough estimate of cognitive capacity. In all of the experiments which will be reported, no significant differences on these two measures were found ($p > .05$). The subject data for all experiments are presented in Table A-1.

Completed research. One method of empirically separating storage and retrieval has been to compare recall to recognition performance. When a recognition task rather than recall is used to test retention, the typical memory difference between age groups is not found (e.g., Craik, 1972). Two hypotheses can account for the failure to find age differences in recognition memory. The first hypothesis is based on the assumption that the difference between recall and recognition is an additional search process necessary to perform the recall task (Murdoch, 1974). A second hypothesis explains the results in terms of a storage decrement based on the assumption that a subject can learn parts of the presented information. This partial information, while inadequate to recall the item, is

Table A-1
Subject Information from All Reported Experiments

Experiment	Subject pool	Age group	Age range	N	Digit span	Vocabulary
1. Recognition experiment	Civic clubs	Gp. 1	20-49	41	xxxx	24.21*
		Gp. 2	50-69	30	xxxx	24.30
		Gp. 3	70-90	41	xxxx	26.17
2. Cued recall experiment	alumni	Gp. 1	20-39	24	7.75	28.25
		Gp. 2	40-59	24	7.63	28.17
		Gp. 3	60-80	24	7.25	30.96
3. List length and presentation time experiment	alumni	Gp. 1	20-40	12	7.58	32.08
		Gp. 2	41-60	12	7.75	32.25
		Gp. 3	61-80	12	7.25	33.25
4. Study/recall experiment	alumni	Gp. 1	20-50	40	7.65	29.31
		Gp. 2	51-80	40	7.37	31.45
5. Mnemonic experiment	alumni	Gp. 1	20-39	24**	7.87	30.92
		Gp. 2	40-59	24	7.20	30.25
		Gp. 3	60-80	24	7.38	31.67

*Vocabulary score represents second half of WAIS vocabulary sub-test.

**N represents only mnemonic condition. The data were compared with an earlier experiment (Smith, 1975) which had identical materials and experimental conditions.

sufficient to produce correct recognition. In the present experiment, a test of the storage (partial learning) and retrieval hypotheses was attempted by minimizing the opportunities for subjects in three different age groups to use partial information while performing the recognition task. Partial storage was minimized by using stimuli which were well integrated into units and difficult to store partially. Single syllable, high-frequency nouns and verbs were used as stimuli. The recognition test list was designed to further reduce the use of partially stored information. Distractor items in the test list closely resembled the presented items along both structural and semantic dimensions.

Twenty-five high frequency (A or AA) words from the Thorndike and Lorge (1944) norms were selected such that additional words could be chosen which differed from the original by one letter (structural fillers), and words could be chosen which were synonyms of the original (semantic fillers). The list was presented at a 2-second rate by a slide projector onto a large screen in front of the room. A magnetic tape timed and controlled the experimental sequence and presented the instructions. The first five and the last five words in the list were not tested for recognition and served as buffer items to minimize the effects of primacy and recency. The 15 words from the middle of the list together with the distractors were presented in the answer booklet. Sufficient time was allowed for all subjects to complete the recognition test list. Three different random orders of the test list were used, while the same order of words in the presentation list was used for all subjects.

The mean number of hits (correct recognitions) and false alarms (saying "yes" to distractors) are presented in Table A-2. The number of correct recognitions was approximately equal for all three age groups. The same is true for the structural and unrelated false alarms. A significant age difference, however, was found in the number of semantic false alarms, $F(2,109) = 3.24$, $p < .05$. While the absolute number of errors was quite small for all age groups, the oldest group made almost twice as many semantic errors than the youngest group. Because hit scores and false alarms are influenced by decision processes as well as memory processes, difference scores (hits minus false alarms) and d' scores (derived from signal-detection theory) also were computed and are presented in Table A-2. No significant age differences were found in either the difference scores ($p = .56$) or the d' scores ($p = .48$). The type of distractor, however, did prove significant, $F(2, 218) = 18.94$, $p < .01$. This effect was due to the greater difference scores obtained with the unrelated distractor items.

Table A-2
Recognition Memory Performance in the Three Age Groups

Age Gp.	Mean Hits	Struc. FA's	Sem. FA's	Unr. FA's	Difference scores (d' scores)		
					Struc.	Sem.	Unr.
1	13.7	1.0	.92	.49	12.7(2.9)	12.7(2.9)	13.2(3.2)
2	13.2	1.3	1.30	.50	11.9(2.6)	11.9(2.6)	12.7(3.1)
3	13.4	1.3	1.70	.50	12.1(2.7)	11.7(2.5)	12.9(3.1)

The recognition-memory paradigm was chosen because it allowed differential predictions based on the assumptions of the two hypotheses. Yet, both hypotheses gained some support. The retrieval hypothesis predicted the outcome found with the difference and d' scores. The partial-learning hypothesis received some support by the fact that older persons made a greater number of semantic errors in the test. The present task, like most laboratory tasks in memory research, dealt primarily with episodic memory. The subjects were asked to identify words they had recently seen in the presentation list. Recognition performance, as a measure of episodic memory, suggests that older persons have a greater difficulty in searching their memories in order to retrieve information recently stored. When the search requirements of the recall task are minimized with the recognition procedure, memory differences between the age groups were eliminated. The difference in semantic errors suggests an additional problem that might be present in the older person's storage into semantic memory. It is difficult to interpret this difference as criterion or decision differences because (a) no differences were found with the other two false alarm types, and (b) older persons have been found to be more cautious, rather than less cautious, in making decisions (e.g., Slater & Scarr, 1964). Experiments are proposed later which will examine possible semantic memory differences between adult age groups.

The recognition procedure as a test for retrieval has generated some recent controversy (e.g., Watkins & Tulving, 1975) and so other procedures were used to support these findings. One experiment utilized the comparison of cued recall with non-cued recall. If the aged have greater retrieval difficulty, then providing cues at the time of recall should help reduce this difficulty and thus reduce the difference between the age groups. Some experiments have found a facilitative effect of cued recall in the older groups (Hultsch, 1975; Laurence, 1967), but one experiment failed to find an interaction with age (Drachman & Leavitt, 1972). The reason for the conflicting results could be the nature of the cues provided at the time of recall. Drachman and Leavitt (1972) used structural cues (the initial letter in the item) while the other experimenters used conceptual or semantic features as the cue (category names). The present experiment used both kinds of cues.

Twenty words were selected which were middle-frequency (100-150) responses from the Battig and Montague (1969) category norms. The words all had different initial letters and represented different conceptual categories (e.g., fruits, vehicles, etc.). Half of the subjects received the cues at input and half did not. In addition, half of the subjects got semantic cues (category names) while the other half got the initial letter cues. After the presentation of the list at a 2-second rate, all the subjects received three minutes of free recall (non-cued) followed by three minutes of recall with the cues present. The results of the experiment are presented in Table A-3. Age, $F(2,60) = 9.19$, $p < .01$, and cue type, $F(1,60) = 21.14$, $p < .01$, were significant, i.e., performance was poorer with the structural cues and poorer in the older age groups. In cued recall, the semantic cues improved recall while the structural cues did not (Cue type x Cue presence at output, $F(1,60) = 37.39$, $p < .01$).

Table A-3
Mean Free and Cued Recall

	Semantic cues		Structural cues	
	Non-cued at input	Cued at input	Non-cued at input	Cued at input
Group 1				
Non-cued recall	11.7	9.5	10.3	9.0
Cued recall	<u>12.7</u>	<u>12.2</u>	<u>9.3</u>	<u>8.2</u>
Group 2				
Non-cued recall	8.0	9.3	8.2	7.7
Cued recall	<u>9.7</u>	<u>12.3</u>	<u>7.5</u>	<u>7.0</u>
Group 3				
Non-cued recall	6.0	9.8	6.5	5.8
Cued recall	<u>8.7</u>	<u>11.7</u>	<u>5.2</u>	<u>3.5</u>

Note. Underlines indicate data in second analysis.

Although no interactions were found with the age variable, a separate analysis was done comparing the two conditions where the

cues were either present at both or absent from both input and output. These conditions are underlined in the table and are seen in Figure A-2. Providing semantic cues essentially removed the age effect in the recall data. The structural cues, however, were ineffective in changing recall. The experiment supports the retrieval hypothesis,

in that providing effective (semantic) retrieval cues at the time of recall brings the performance of the older group up to that of the younger group.

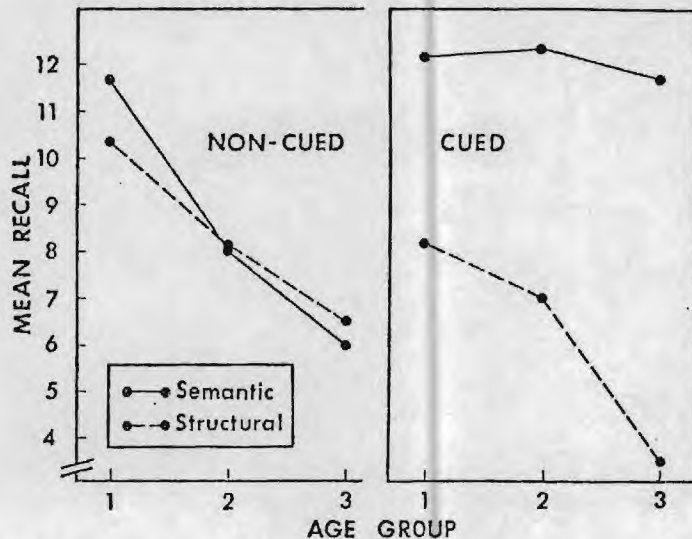


Figure A-2. The mean recall of the different age groups for conditions of cued and non-cued recall.

A third experiment varied the relative importance of storage and retrieval in performing a task by using the study/recall method developed by Tulving (1967). The number of study and test sessions was varied between conditions in order to examine learning in different age groups with tasks differing in the importance given to storage and retrieval processes. A list of 20 unrelated words, equated in meaningfulness and frequency, were presented at a 3-second rate during the study sessions

making the total presentation time for the list 60 seconds. Retention tests also lasted 60 seconds, thereby equating the time interval required for both study and test sessions. An experimental cycle consisted of four sessions, with the number of study and test components varied between groups. One group of subjects received one presentation of the list (study) followed by three successive test periods (STTT). A second group received three study sessions followed by a single test period (SSST). After four four-session cycles (16 sessions), all subjects were given one additional presentation followed by a final critical fifth-cycle test. Half of the subjects were tested by free recall and the other half were tested by recognition. Two age groups were used with 40 subjects in each group. The experimental sequences were:

Session -	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
(SSST)	S	S	S	T	S	S	S	T	S	S	S	T	S	S	S	T	S	T
(STTT)	S	T	T	T	S	T	T	T	S	T	T	T	S	T	T	T	S	T

The acquisition data (first 16 sessions) are presented in Figure A-3. Comparisons between age groups are made with the division at age 50. It is interesting to observe the difference between the SSST and the STTT conditions when recall was the method of test. Little difference between the age groups is seen with the SSST condition, while the older group shows a deficit in the STTT condition. While this difference is significant when the recall data

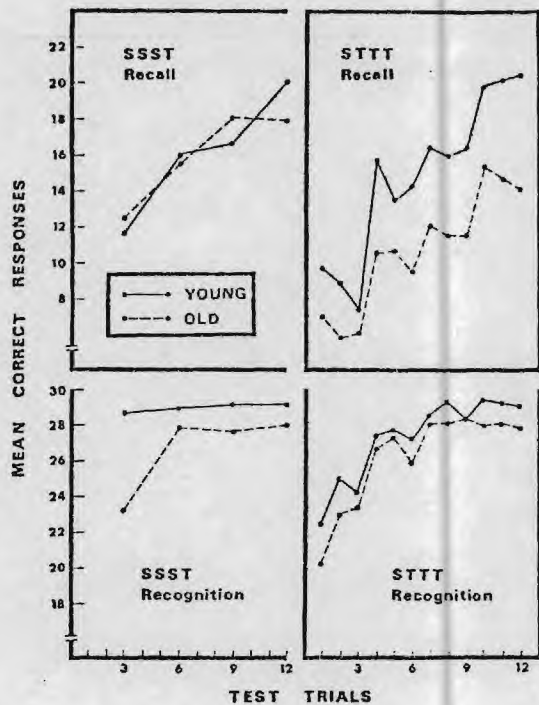


Figure A-3. Mean performance for the two age groups.

alone are examined, the significance of the interaction between age and method of presentation (SSST vs. STTT) was not found in the overall analysis.

Analysis of covariance, with vocabulary as the covariate, was performed on both mean acquisition performance and the critical last test in the fifth cycle. Both analyses showed equivalent results. Age and method of test (recall vs. recognition) were significant main effects ($p < .01$). Method of study, however, failed to reach significance. This result replicates Tulving's (1967) finding. The Age x Method of test interaction was significant ($F=4.03$, $p < .05$) showing that the difference between the age groups was greater in the recall conditions than in the recognition conditions. Except for the first test trial in the SSST condition, no differences were found between the age groups on the recognition task. This replicates the earlier study reported in this section.

The Age x Method of presentation interaction discussed earlier approached significance ($F=3.38$, $p=.0554$). As stated earlier, the interaction is significant when the recall data alone are examined. While the results suggest that the age problem is primarily one of retrieval, the lack of an acceptable level of significance clouds the conclusion. In the recall data, however, the results are clear. The STTT task requires a greater amount of retrieval on the part of the subject, and the older subjects with inadequate retrieval processes do not do well on this task. The SSST condition shows no such age effect. Again, the results indicate retrieval problems on the part of the elderly.

A fourth experiment looked at retrieval in the different age groups by manipulating two task variables, presentation time and list length, which are assumed to affect retrieval differently. These variables combine to form the total-presentation-time parameter. Evidence from several studies discussed earlier have shown that the older person is both less efficient at using the time available to perform cognitive tasks, and at the same time, less effective at retrieving information recently presented into memory. A split-plot design was used combining presentation rate (1.5 vs. 3.0 seconds), list length (15 vs. 30 items), and subject age. All 36 subjects served in all conditions. The order of the lists was counterbalanced across subjects. The list items were randomly selected, high-frequency (AA) words. Three minutes were allowed for the recall of each list.

The results of the experiment can be seen in Figure A-4. All three main effects were significant: age, $F(2,33) = 30.1$, $p < .01$;

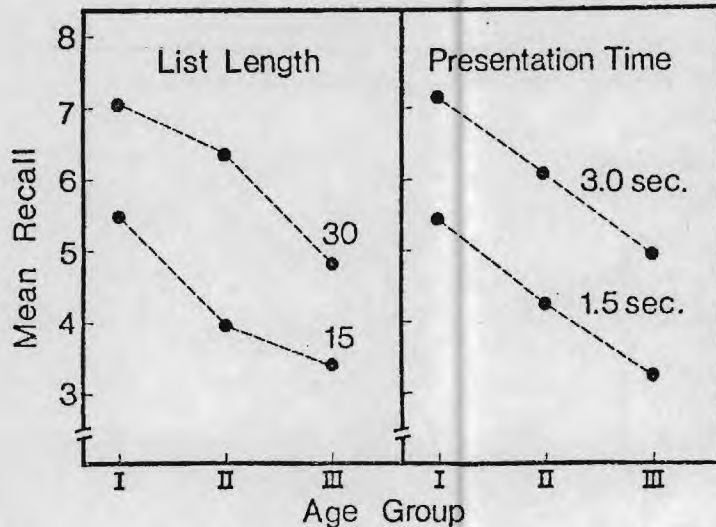


Figure A-4. The effects of presentation time, list length and age on recall.

accounted for a striking 99.7% of the variance.

Within the constraints of the present design and within the restricted range of the manipulated variables, the total-presentation-time hypothesis equally predicted recall in both the young and old. In fact, a comparison of the current data with Murdock's (1960) original experiments reveals consistent total-time equations:

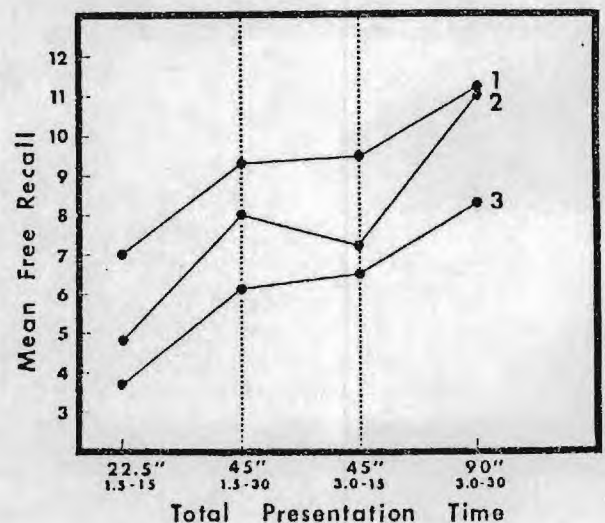
$$\begin{aligned}
 R &= .06t + 6.1 && \text{(Murdock's equation with college-aged Ss)} \\
 R &= .06t + 6.1 && \text{(Group 1 - aged 20-40 years)} \\
 R &= .06t + 2.7 && \text{(Group 3 - aged 61-80 years)}
 \end{aligned}$$

The slopes for these two age groups are identical. In fact, it was the overall level of recall that differentiated the groups as evidenced by the different intercept points. In addition to the linearity component, the results also tend to support the invariance component of the total-time hypothesis. As can be seen in Figure A-5, little difference is seen in the recall of the two 45-second lists. A comparison of Groups 1 and 3 shows parallel horizontal functions. A slight decline is seen in Group 2, but this difference is non-significant ($t_{dep} = 1.14, p > .01$), and in the opposite direction of the predicted outcome with the older groups. It was hypothesized that increasing list length or decreasing presentation time would have a more detrimental effect in the older subjects. This result was not found.

The findings with presentation time were not too surprising in light of the fact that most

list length, $F(1,33) = 35.8, p < .01$; and presentation time, $F(1,33) = 29.4, p < .01$. No interactions with age, however, were significant. The relationship between total time and recall is presented in Figure A-5. Little difference is seen in the slopes of the recall functions. With the two 45-second conditions averaged, analysis of variance revealed significant effects of age and total time ($p < .01$). The anticipated interaction between total time and age was not found. To test the linearity component of the total-time hypothesis, a trend analysis was performed on the data. The linear trend was significant ($p < .01$) and

Figure A-5. Mean free recall as a function of total time for the three age groups.



experiments showing temporal interactions with age have found a deficit with response time and retrieval time. Many experiments have shown that study time or presentation time is not as effective in manipulating the recall differentially in different age groups.

The findings with list length are more surprising. Craik (1968a), for example, had previously reported a differential effect of list length on the recall of young and old subjects. One possible difference between Craik's experiment and the present one, is that Craik's short list contained fewer items (10 instead of 15) and this means that the result could reflect different influences of primary memory in the two experiments. Much research has shown that the age deficit in recall is found only when secondary memory is tested, primary memory being unaffected by increasing age. Within the range of list lengths used for the short lists in the two experiments, there is a possible differential influence of primary memory in recall. The list length effect in Craik's experiment might be due to the fact that a large proportion of the short list was recalled from primary memory where no age deficit would be expected, and the long list was recalled primarily from secondary memory where the age deficit is found.

An experiment is proposed which includes list lengths from both the Craik (1968a) experiment and intermediate lengths like the present experiment. More than two list lengths will be used to determine possible confounding with primary memory. In addition, the experimental procedure is designed to look at list length effects due to retrieval and those effects due to storage (Shiffrin, 1970).

In summary, four experiments have been discussed, and with the exception of the list length effect which deserves further research, the results support the hypothesis that the episodic memory problem seen in old age is due to faulty retrieval at the time of test. An additional experiment was conducted which tested the effectiveness of a mnemonic device to overcome the retrieval handicap in the older group. An imagery-based mnemonic system, called the rhyme peg-word system, was taught to three age groups (one is a bun, two is a shoe, three is a tree, etc.). A paired-associate probe technique, which was developed by Arbuckle (1967) and recently used in different age groups without mnemonic instructions (Smith, 1975), was used in the experiment. The subjects were first taught the mnemonic device and given practice in the use of the device until they easily could recite it. The subjects were then administered eight single-trial paired-associate lists using the study-recall method. First the eight pairs were presented at a 5-second rate. The stimuli for all lists were the digits 1-8, and the responses were common words, each list using responses from a different conceptual category. After presentation, the eight lists were presented one at a time and the subject was given five seconds to produce the responses which were paired with the digits. The input position of the pairs always corresponded to the numerical order of the digits. The output position was counter-balanced such that across all eight lists, each input pair was represented at all output positions. The experimental conditions and word lists were exactly the same as used in a previous experiment in this project (Smith, 1975). The results, therefore, could be compared with the previous results to determine the effectiveness of the mnemonic instructions in the present experiment. The only difference between the two experiments was that the subjects were taught to use

the pegword mnemonic device in the present experiment.

The input positions were blocked into pairs and serial position curves for the data are presented in Figure A-6. It should be remembered that any input position was tested at all eight output positions. This reduces the recency portion of the curve. The figure clearly demonstrates that the mnemonic effect was found only with the younger group. The older groups showed no beneficial effect of mnemonic instruction. In fact, there was a detrimental effect of the mnemonic for the primacy positions in all three age groups.

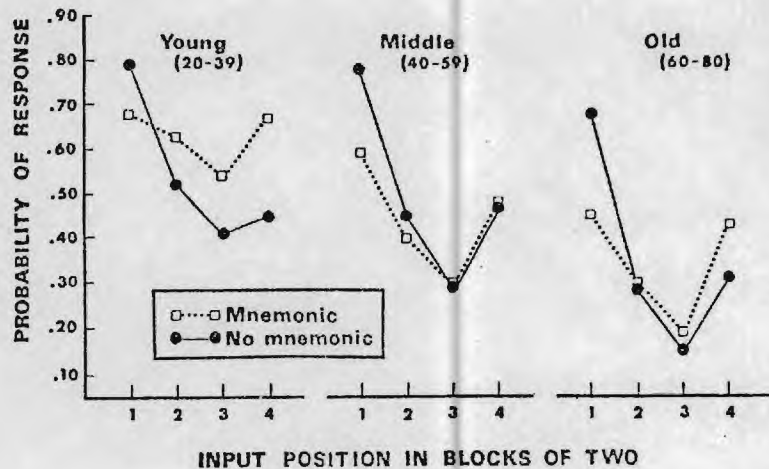
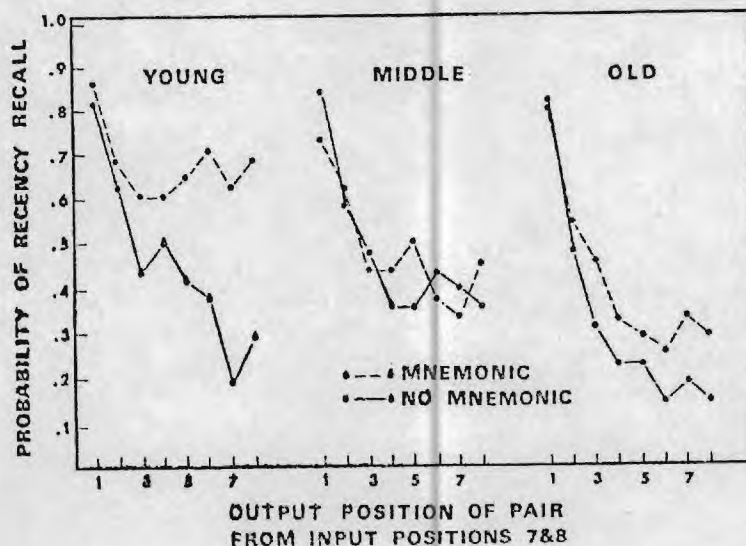


Figure A-6. Input serial position curves for the three age groups under conditions of mnemonic and non-mnemonic instruction.

and therefore represents the content of primary memory, the functions plotted in Figure A-7 can be considered primary memory functions. Again, no differences between the mnemonic and non-mnemonic conditions are seen in the two older age groups. In the young group the difference is seen only at the later output positions. Recency recall at early output positions is from primary memory. With interpolated outputs, however, the ability to use primary memory decreases. At

Figure A-7. Recency recall across the eight output positions.



Because recency was confounded with all eight output positions, a separate analysis was performed on the recency input positions (Input positions 7 and 8) alone. The probability of recall of items from these positions is plotted in Figure A-7 against the output positions of the pairs. Because recency is the last information seen in the list

the later output positions, therefore, recall is based on secondary memory where mnemonic effects would be expected and in fact are found in these data.

It was expected that mnemonic instruction would benefit the older groups more than the younger groups. The results, however, indicate the opposite. Mnemonic effects were found only for the young group. One reason for the results might be the fact that imagery instructions were used extensively in the present experiment. Previous research has indicated that

older persons might be less able to effectively use visual imagery in learning tasks (e.g., Hulicka & Grossman, 1967). One experiment is currently being conducted (discussed in next section) which is manipulating instructions to image as a variable in three age groups. This experiment should show that imagery instructions are beneficial only in the young group if ability to image is the reason for the mnemonic failure. Another experiment is proposed which will vary conditions assumed to be important in determining the effectiveness of mnemonic devices. One such variable will be the type of instruction. Some subjects will be told to use visual imagery while another group will be told to use verbal association, i.e., to form a sentence using the pegword and the to-be-remembered word. It is expected, based on the results of mnemonic results discussed earlier, that the verbally based mnemonic will produce best performance in the old subjects, while the imagery based mnemonic will produce best performance in the younger subjects.

Research in progress. Two experiments are currently being conducted but are yet incomplete. One experiment, as mentioned earlier, is examining the effectiveness of imagery instructions in different age groups. A list of words containing both abstract and concrete items is being presented to groups differing in age under two types of instruction. One group is being instructed to use visual imagery, to picture the words as they are presented. The other group is being told to remember the words as best as they can (standard free recall instructions). The results of this experiment should clarify the reasons for not obtaining a mnemonic effect in the previous experiment. If the failure of imagery-based mnemonics is due to the fact that older subjects can not use imagery as effectively as younger subjects, then imagery instructions should produce less facilitation in the older group.

A second experiment is examining the nature of the organizational structures used by different aged subjects. While earlier experiments have indicated no differences between age groups in the amount of organization found in recall protocols, this experiment is also examining the possibility that differences might exist in the type of organization. A list of words which contains different types of association between the items is being presented for multi-trial free recall. Some of the words are conceptually related (Battig & Montague, 1969); some of the words are associatively related (Deese, 1969); and some of the words are structurally related (acoustic, graphemic, and alphabetic similarity among the items). Example groupings are:

Conceptual - Dog, horse, cow, lion, pig, bear; Red, green, orange yellow, purple, pink. (Response values > 100)

Associative - Music, song, note, horn, instrument, piano; Slow, fast, run, walk, quick, speed. (Associative overlap $> .30$)

Structural - Fight, night, right, light, sight, bite; Storm, star, store, strong, stick, state.

In addition to clustering along these three dimensions, subjective organizational measures will be computed across five acquisition trials (Gorfein, Blair, & O'Neill, 1969). Because young subjects will probably recall more words than old subjects, the measure

employed by Cole, Frankel, and Sharp (1971) is being used which normalizes the clustering scores for differences in the total number of words recalled.

d. Publications. (Published or accepted for publication in period of current progress report.)

Smith, A. D. Response interference with organized recall in the aged. Developmental Psychology, 1974, 10, 867-870.

Smith, A. D. Aging and interference with memory. Journal of Gerontology, 1975, 30, 319-325.

Smith, A. D. Partial learning and recognition memory in the aged. International Journal of Aging and Human Development, 1975, in press.

Smith, A. D. Aging and the total-presentation-time hypothesis. Developmental Psychology, 1975, in press. (Paper presented to the meeting of the American Psychological Association, Chicago, September, 1975.)

e. Staffing. The principal investigator on this its beginning has been Anderson D. Smith, Associate Professor of Psychology. Graduate student assistants for the current period have been Susan E. Mason, James C. Domangue, Jr., Flora F. Crew, and Kenneth E. Jackson.

Experiment 3 in the progress report (Study/test components) was conducted as a Masters thesis by Flora F. Crew. Ms. Crew was responsible for the running of the subjects and the analysis of the data.

B. SPECIFIC AIMS

Two experiments involve investigations of the retrieval process in episodic memory and possible changes in the process due to age.

1. In one experiment, list length will be manipulated such that the interaction between age and list length can be assessed, and the extent to which the effects are due to differential storage and retrieval can be evaluated.
2. A second experiment will examine the conditions that produce facilitative recall in older persons when using mnemonic devices as retrieval aids. Variables which are assumed to be important in the effectiveness of mnemonic devices will be manipulated. List concreteness, device concreteness, study time, and instructions will be systematically examined in different age groups.

Experiments are also proposed which will examine storage and retrieval processes of semantic memory in different age groups. The possibility of differences in both the nature of the semantic lexicon (storage) and in the retrieval and utilization of information from semantic memory will be studied.

3. One experiment will attempt to determine differences in the structure of semantic memory in older persons by providing category names to subjects of different ages and measuring

responses given to the category name. The format and variability of the resultant normative data will be analyzed as function of age.

4. Three hypotheses which account for the greater amount of time taken by older persons to make a semantic response (i.e., category-size, decision, and retrieval hypotheses) will be tested by varying normative category size and measuring the amount of time it takes subjects from different age groups to respond (reaction time) in a semantic memory probe task.
5. The storage and retrieval of information received in the form of sentences will be examined in three different age groups. The hypothesis that older persons have greater problems in abstracting semantic ideas from text material will be tested.

C. METHODS OF PROCEDURE

Experimental procedures: Each proposed experiment will be described in the approximate order in which the experiments will be conducted.

Experiment 1 - Aging and list length.

The first experiment will clarify the effect of list length on the storage and retrieval processes of different aged subjects. Three groups of 24 subjects will be presented with a series of ten free recall lists. The three groups will differ in adult age. The words selected for the lists will be unrelated, high-frequency words from the Thorndike and Lorge (1944) frequency norms (A and AA). Each list will be either 10, 20, or 40 items in length. The design of the experiment is presented in Table C-1.

Table C-1
Design Matrix for Experiment 1

Age group	List order	Length of recalled list								
		10			20			40		
		Length of interpolated list								
		10	20	40	10	20	40	10	20	40
Young (20-39)	1 (N=8)									
	2									
	3									
Middle (40-59)	1									
	2									
	3									
Old (60-80)	1									
	2									
	3									

The number of list lengths is limited to three because of the necessity of keeping the experimental session sufficiently short to prevent fatigue. The 10-item list was the short list in the Craik (1968a) experiment. The 20-item list is well beyond the immediate memory span. This comparison, therefore, will allow an examination of possible primary memory effects between these two lists. If differential list length effects due to age are found between the 10 and 20 item lists but not between the 20 and 40 item lists, the primary memory argument will be supported.

Each subject will be represented at all nine list-length conditions. The two variables are the length of the list being recalled and the length of the list intervening between presentation and recall (Shiffrin, 1970). Subjects will be asked to recall, not the list just presented, but, instead, the list presented just before the last one seen. This allows a separation of effects due to storage decrements, i.e., list length as an interfering activity, and effects due to retrieval difficulty.

Three orders of lists will be used in the experiment. Each list length is represented equally at all positions in the order sequence. A buffer first list will be included to reduce any "warm-up" or non-specific transfer effects. This list is not included in the analysis.

Order 1 -	(20)	10	20	20	40	20	10	10	40	40	10
Order 2 -	(20)	20	40	40	10	40	20	20	10	10	20
Order 3 -	(20)	40	10	10	20	10	40	40	20	20	40

After each list is presented, subjects will be given three minutes to recall orally from the list preceding the one presented. The total experimental session should last only 45 minutes.

If list length effects are primarily due to retrieval, then the length of the recalled list will be the important variable. If list length effects are due to interference with storage, then the length of the interpolated list (amount of interference) will prove important.

Experiment 2 - Conditions determining the effectiveness of mnemonic devices in the aged.

The variables of list concreteness, device concreteness, instructions, and presentation rate will be examined in this experiment, as variables assumed to be important in determining the effectiveness of mnemonic devices. Age, device concreteness, and instructions will be manipulated between subject groups, and presentation rate and list concreteness will be manipulated within subjects. The design of the experiment is presented in Table C-2. Eight subjects will be represented in each cell of the design. The four within-subject conditions will be counterbalanced using a balanced Latin square. Within each cell two subjects will receive each of the four order sequences. List concreteness will be determined by consulting the Paivio, Yuille, and Madigan (1968) concreteness norms. The words will be equated on frequency. The abstract and concrete devices will be the standard ones used in previous research (Paivio, 1968; 1971). Presentation time for each word will either be five seconds or self-

paced (subject controlled). Either imagery instructions or verbal mediation instructions (form a sentence with the two words in it) will be given. Examples of the use of imagery or verbal association will be given in the instructions. All subjects will be given sufficient time to learn the mnemonic device (pre-training) and sufficient time to respond.

Table C-2
Design Matrix of Experiment 2

INSTRUCTIONS	DEVICE	AGE GROUP	Concrete list		Abstract list	
			Self-paced	5-sec.	Self-paced	5-sec.
Imagery	Concrete	1 (N=8)				
		2				
		3				
	Abstract	1				
		2				
		3				
Verbal mediation	Concrete	1				
		2				
		3				
	Abstract	1				
		2				
		3				

The above two experiments deal primarily with episodic memory and the problems old persons have in retrieving information from episodic memory. Subjects are asked to retrieve information according to a temporal tag, i.e., words recently seen in a list. The following experiments deal with semantic memory and the problems older persons have in storing, retrieving, and utilizing information from this memory system.

Experiment 3 - The nature of the semantic lexicon in different age groups: A normative study

This experiment proposes to gather category norms for subjects from different age groups and to use these norms to infer possible differences in the nature of semantic memory due to age. A list of category names will be given to the subjects, and they will be asked to give up to 10 responses (instances of the category) for each category name. The category list will include the categories from the Battig and Montague (1969) norms (56 categories) in addition to a list of categories not included in the list. The additional categories will be exhaustive categories used in Experiment 4. In addition to the collation of the norms, several additional measures will be examined. For example, the potency of the categories across age groups will be measured. Potency can be rated (how many

responses can you make for this category name?) or can be computed from norms which restrict the amount of time allowed for responding. The Battig and Montague (1969) norms were constructed in this fashion. Because older subjects have slower response times (Eysenck, 1975), time constraints will not be placed on the subjects in this experiment. Instead, ratings of each category will be collected prior to generating the instances. A seven point rating scale (with verbal anchors) will be used. Battig and Montague (1969) showed a correlation between scaled potency and computed potency to be .70.

In addition to the value provided by these norms to further memory research using different age groups, the results should give some insight into possible differences in semantic memory for the different age groups. For example, if the subjective categories increase in size with age, a greater variability in the responses given to the category name would be expected in the older groups.

Experiment 4 - Reaction time as an indication of semantic memory in different aged subjects.

Questions of the form, "Is an apple a fruit?," will be asked of subjects from different age groups, and the time it takes the subjects to reach yes/no decisions will be measured. Such questions tap semantic memory, and the experiment is designed to differentiate between three hypotheses which account for the finding that older persons take more time to respond to semantic information than younger persons. The independent variable in the experiment will be the normative size of the category. In addition, categories which can be easily enumerated will be included in the design. The design of the experiment is presented in Table C-3.

Table C-3
Design of Experiment 4

Age group	Normative category size			
	Exhaustive	Small	Medium	Large
1 (20-39)				
2 (40-59)				
3 (60-80)				

The categories to be used in the experiment were selected from the Battig and Montague (1969) category norms and normative category size was determined by the number of different responses given by four or more respondents. The categories are listed in Table C-4 together with the computed potency values from the Battig and Montague norms. An attempt was made to select categories with similar potency values since this measure is the average number of items generated in 30 seconds by the subjects. This measure can serve, therefore, as an estimate of the strength between the category name and the instances. The mean potency values for the different sets of categories is also presented in Table C-4.

Becasue subjects of different ages might read at different

rates, the questions will be asked in the following manner. First, the category name will be presented for two seconds. Then, following a two-second interval between the slides, a target word will be presented. The presentation of the target word will initiate the reaction-time clock which will be terminated by the subject's response. The subject will press one key if the response is "yes" (the target word is an instance of the category) and another key if the response is "no" (the target word is not an instance of the category). The response made by the subject and the time to make the response will be recorded. Each of the categories will be tested four times, two times with "yes" targets, and two time with "no" targets. In addition to the categories listed in the table, some additional categories will be included in the testing sequence. These categories will be hierarchical like the ones used by Collins and Quillian (1969) and Smith, Shoben, and Rips (1974). For example:

Categories: Dogs Animals Living things
Target: Collie

With these categories, category size is manipulated by the level of the hierarchy to be searched to find the target word. In other words, it should take longer to say that a collie is an animal than to say that a collie is a dog.

Table C-4
 Categories to be Used in Experiment 4

Exhaustive	$f < 40^2$	$40 < f > 70$	$f > 70$
Seasons (4) ¹	Vegetable	Part of building	Girl's first name
Days of week (7)	Alcoholic Beverage	Part of human body	College
Parts of speech (10)	Color	Kitchen utensil	Occupation
Months of year (12)	Metal	Tree	Weapon
States (50)	Fruit	Bird	Country

¹Numbers in parentheses refer to actual number of instances in exhaustive categories

² f is computed as the number of items given four or more times in the Battig & Montague (1969) category norms. This serves as an approximation to normative category size.

Potency values (\bar{x}) for the four types
 of categories:

Exhaustive	7.94
$f < 40$	7.57
$40 > f < 70$	7.96
$f > 70$	7.63

It should be re-emphasized that absolute differences in reaction time between age groups are not important in this experiment. The important predictions involve interactions between age and the category size variable. The fact that older persons are slower in reaction time experiments, i.e., the main effect of age, does not interfere with the predictions of interaction between the two variables.

Experiment 5 - Sentence memory and the abstraction of semantic ideas in different age groups.

The experimental session will consist of two parts. During the first part, sentences will be presented, one at a time, to the subject for later recognition. The second part involves a recognition test for sentences, some of which appeared in the list and some of which are new. The subject will be instructed to choose only those sentences which are exactly as presented in the previous list. This method has been used by Bransford and Franks (1971) to investigate the abstraction of semantic ideas. While the format of the experiment is designed like an episodic memory experiment, the design allows inferences about how subjects encode semantic ideas into memory. The presentation list will include four sets of sentences, each set consisting of four simple ideas. The sentences are either statements of a single idea (one) or combinations of the ideas formed into complex statements (twos or threes). The sentences used in the Bransford and Franks (1971) experiment are presented in Table C-5. The sentences marked t are only presented at the time of test and the sentences marked a are presented only during acquisition.

Table C-5
Sentences Comprising a Complex Idea^{a,b}

FOUR:	(t)	The ants in the kitchen ate the sweet jelly which was on the table.
THREE's:	(a)	The ants ate the sweet jelly which was on the table.
	(a)	The ants in the kitchen ate the jelly which was on the table.
	(t)	The ants in the kitchen ate the sweet jelly.
TWO's:	(a)	The ants in the kitchen ate the jelly.
	(a&t)	The ants ate the sweet jelly.
	(t)	The sweet jelly was on the table.
	(t)	The ants ate the jelly which was on the table.
ONE's:	(a)	The ants were in the kitchen.
	(a)	The jelly was on the table.
	(t)	The jelly was sweet.
	(t)	The ants ate the jelly
Other	(t)	The warm breeze blowing from the sea stirred the heavy evening air.
FOUR's:	(t)	The rock which rolled down the mountain crushed the tiny hut at the edge of the woods.
	(t)	The old man resting on the couch read the story in the newspaper.

^a From Bransford and Franks (1971)

^b a, acquisition; t, test.

The listeners from the three age groups will hear 24 sentences, six from each of the four unrelated sets. Sentences from the four sets will be interspersed so that the subject will have difficulty linking the ideas together. The recognition test list will be 28 sentences most of which will not have been presented during acquisition. College-aged subjects recognize the complex ideas (fours) as presentation sentences even though they were not presented during acquisition (Bransford & Franks, 1971).

If the older group is deficient at abstracting ideas from the sentences, then recognition memory could actually be better than the

young, since they would reject the complex-idea sentences more frequently than the young. In any case, the recognition performance of the older group would be less predictable on the basis of the idea structures than performance of the younger group.

Human subjects. The procedures for obtaining experimental participants will be the same as used in the previous experiments reported earlier. Subjects will be either Georgia Tech alumni who volunteer to participate in the experiment, or club members who participate as an activity of their club meeting. All subjects will be given the opportunity to refuse to participate at any time and are told about the experimental requirements before agreeing to participate. The requirements for the subject population used in these studies are that they be active, non-institutionalized, healthy members of their communities. All subjects are volunteers and are paid a small sum (usually \$3.00) if they attend the laboratory.

There are no risks to the subjects other than the ordinary risks of daily life (e.g., transportation to and from the lab). To insure confidentiality, subject numbers are assigned to the data, and the subject names are never recorded with the subject numbers.

As in the previously reported experiments, subjects in different age groups will be matched as closely as possible for educational level, socio-economic background, and cognitive-test performance. Testing procedures described earlier will be continued. Names are never associated with test performance and the test data are only used in statistical analyses.

D. SIGNIFICANCE

The significance of the proposed research is that it suggests a possible mechanism for the memory problem seen in old age. Research is indicating that faulty retrieval from episodic memory could account for the recall decrement, and experiments are attempting to specify the nature of this retrieval difficulty. Studies have demonstrated, for example, that recognition and semantic cued recall eliminate the difference typically found between age groups. These test conditions are assumed to minimize the retrieval requirement necessary to perform memory tasks.

Research is also examining the utility of mnemonic devices as retrieval techniques to alleviate the memory problem in older persons. Mnemonic systems could be developed at the time of storage (learning) to be used at the time of recall (retrieval). Research is investigating the possibility that verbally-based mnemonic devices are better for older persons than imagery-based ones.

Research is also proposed which examines semantic memory across age groups. Semantic memory is necessary for language use and comprehension, and yet little work has been done on possible interactions between age and the processes of semantic memory. Research does indicate, however, that older persons have greater problems in retaining text material. An investigation of the processes of semantic memory in different age groups could explain this finding.

E. FACILITIES AVAILABLE

The School of Psychology of Georgia Institute of Technology has as much space as is needed for this project (e.g., a waiting room for subjects, a projection room, and an experimental room).

Much of the equipment necessary to conduct the research is also available in the laboratory. Projectors, timers, and tape recorders are available at no cost to the sponsor. Relay programming equipment used to control the sequence of the experimental sessions is also provided, which greatly reduces the equipment costs in the proposed budget.

Modern computing facilities are also available for the reduction and analysis of data, and photographic services for the construction of stimulus materials are available both on and off campus.

F. COLLABORATIVE ARRANGEMENTS

None required.

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